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THE PRACTICAL ENGINEER

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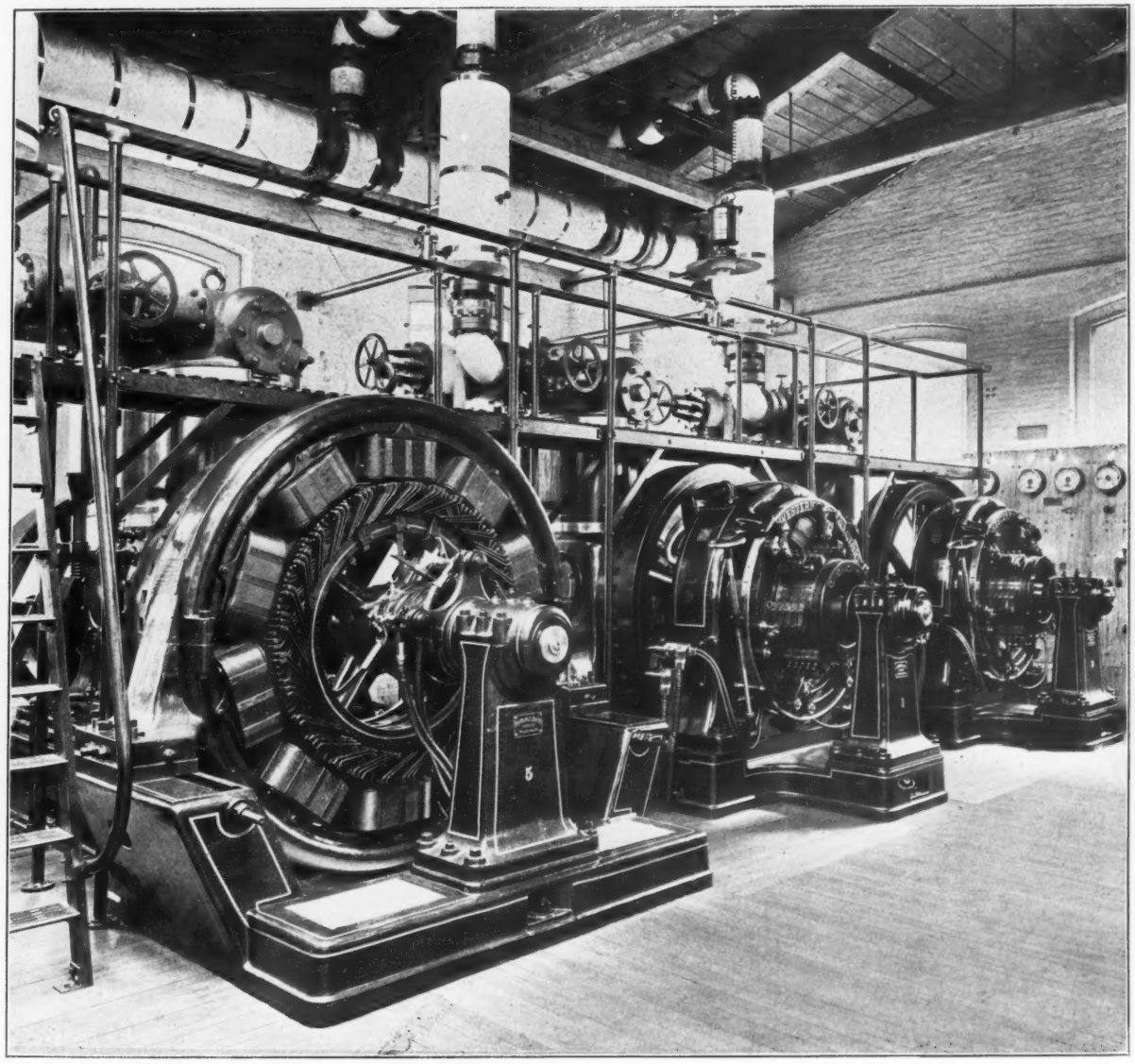

Interior of Engine Room, Sauquoit Silk Mills, Philadelphia, Pa.

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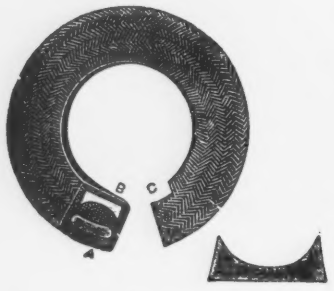

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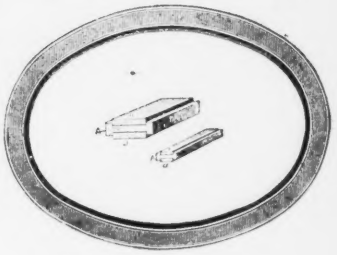

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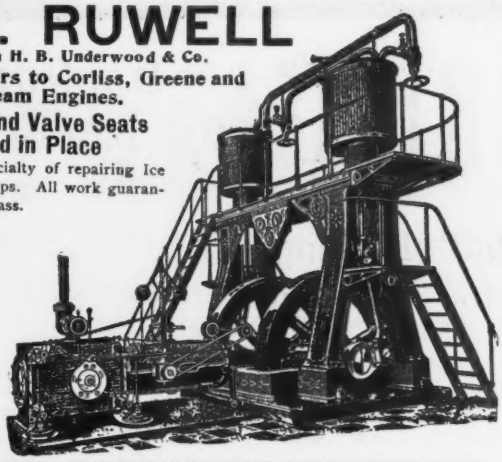

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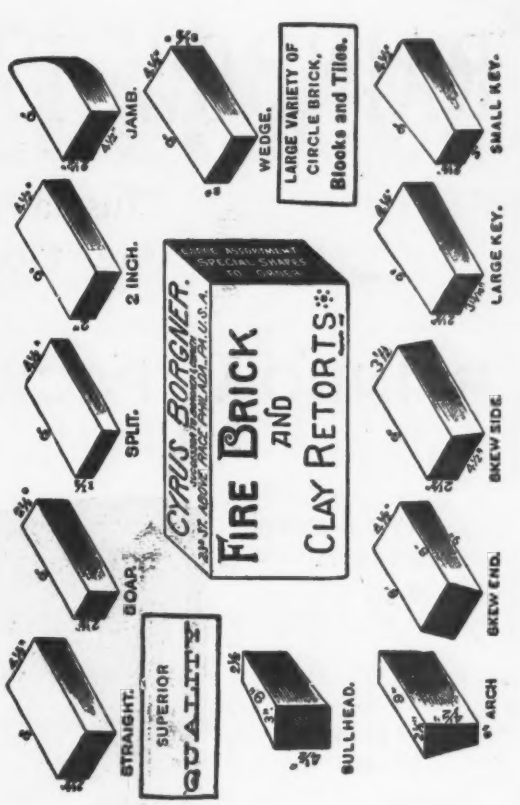

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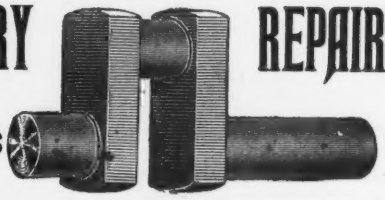

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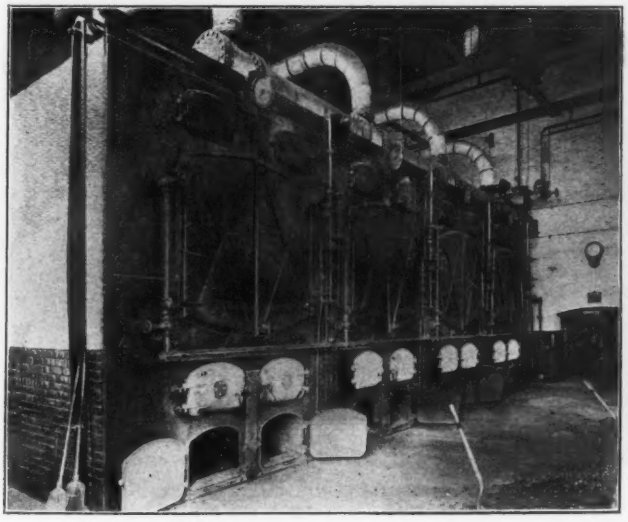
A MOTOR-DRIVEN MANUFACTURING PLANT

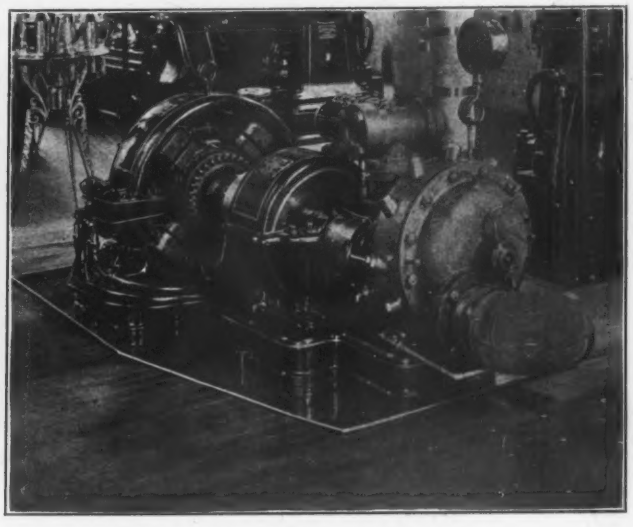
A Large Silk Mill in which a Belt is a Novelty

Since the introduction of electric motors for manufacturing purposes, there has been a gradual development of the application of the direct-driven principle, until, at the present time, there seems to be no class of machines in which this direct motor-driven principle cannot be adopted.

The pioneers of the application of motor-driven silk machinery are the Sauquoit Silk Co., of Philadelphia and New York, and to-day, at their new plant at Nicetown, Philadelphia, there is not a machine, out of the hundreds that are constantly performing all classes of service, that is not direct-driven with its own individual motor and it can be truly said that in this plant, a belt is a novelty.



Four 150 H. P. Return Tubular Boilers.



20 K. W. DeLaval Turbine in Engine Room

To this plant, the silk comes in skeins from China, Japan and India, and after being wound on reels and the ends doubled, the silk is quilled. It then goes to the throwing and twisting machine for making silk tassels or it goes to the warping, copping and beaming machines which prepare the silk into dress goods. Each of these processes demand among other things, that the rooms in which the work is done be very well lighted, very clean and free from oil of any kind, uniform speed and the absence of static electricity. Under the old system of silk manufacture, the use of belts prevented many of these desirable results. The belts would not only throw shadows on the work, but they were dirty and full of static electricity, so that when an end of silk would break, as it often does in many of the different processes, it would immediately fly to the revolving belt and cling to it. Another objectional feature to belting was the overhead shafting and countershafts, with the accompanying hangers and oil cups and the consequent liability of the oil dropping on the silk in the machines below. With the direct-driven machines, all of these difficulties are avoided. The rooms are light and airy, there are no shadows thrown on the work and any regulation of speed on the machines can be obtained independent of any other machine.

The plant of the Sauquoit Silk Company at Nicetown is one

of a number which this Company owns throughout the country, but it is the only silk mill in the world operated exclusively by direct-driven electric motors. The plant covers an area of five acres and consists of ten buildings, well built of brick and so designed that all the departments receive the very best natural light possible. The two main buildings, which are four stories high with basement, contain the main offices, winding machines, doubling machines, quilling machines, throwing machines, warping machines, copping machines and beaming machines. Building number three, which is one story in height with basement, contains the weaving machines on first floor and the electrical department and store rooms in basement. The two-story building, number four, contains the finishing machines, while building number five is where the sizing is done.

Midnight Hour at the Sauquoit Silk Mill

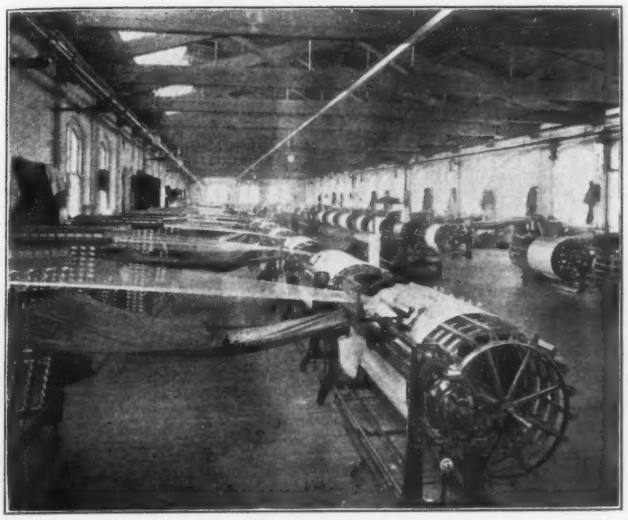
Building number six is the boiler house; building number seven is the engine house; building number eight is the dye house; building number nine is the pump house and building number ten is the oil house.

The power to drive all these machines in the different buildings is, of course, originated in the boiler house. The boiler room contains 4-150 H. P. boilers, 72 inches by 18 feet, of the return tubular type. The boilers are fitted with the usual brass fittings, one Lonergan pop-valve and one Crane lever valve on each boiler. Each boiler has a Reliance water column with high and low water alarms. The self-closing cocks on the water gauges are the P. B. H. type. The boilers are hand fired with pea coal, the flue gases escaping up a circular brick stack, 6 feet inside diameter and 150 feet high, the draft being regulated by a Patterson Damper Regulator.

The pump house contains 3 Barr pumps 7½″ x 5″ x 6″ for service tanks and boiler feed, two Knowles pumps 8″ x 12″ x 12″ for the Warren-Webster vacuum heating system and one Barr pump 5¼″ x 3½″ x 5″ connected to the sewer for emptying the blow-off tank. The fire pump mains and water pipes for the water supply throughout the buildings are led through ducts outside of the buildings, and to prevent the water in the pipes from freezing in the winter, one Knowles pump 4½″ x 2¾″ x 4″ circulates hot water through the ducts. The pump house also contains one Ingersoll-Sargeant air compressor for raising the water from a driven well 319 feet deep. This well was bored to the required depth through rotten rock and mica. The temperature of this water all the year around is about 52 degrees Fahrenheit and has been supplying the mill with 25,000 gallons of water daily, 50 pounds of air pressure being required to raise the water. The discharge pipe from the well is 3 inches in diameter and the air pipe 1¼ inches. The water is discharged into a tank and is distributed to the service tanks or boiler feed.

The engine room which generates the electricity for running the entire plant contains 5 Westinghouse engines of the compound type, 13″ x 22″ x 13″, and one 20 K. W. De Taval turbine. Two kinds of current are generated, 115 volt direct current and 220 volt alternating current. Three Westinghouse engines are directly connected to three Western Electric gen-

erators, having a capacity of 100 K. W. each, when running at a normal speed of 300 revolutions per minute. These machines supply the power throughout the mill, except in the weaving room, as well as the incandescent and arc lighting. The other two Westinghouse engines are connected to Westinghouse three phase alternators, having a capacity of 125 K. W. The



General View of Warping Department. Each Machine is directly connected to a 0.1 H. P. Motor, specially controlled.

alternators supply the power to the 319 motors which drive the looms. The De Laval turbine is of 30 H. P. size, driving a 20 K. W. generator directly connected to it by means of spiral gears. The entire space taken up by this turbine set is 76 inches long, 33 inches wide and 30 inches high. The generator runs at a speed of 2000 revolutions per minute, being geared down from the turbine in the ratio of 10 to 1, the turbine running at a speed of 20,000 revolutions per minute. The turbine unit is used at night for generating direct current for the lamps around the grounds and watchman's lights throughout the buildings and can be used to excite the alternators if the large direct current units are not running. The steam pipes are fitted with Sweet's direct separators over each engine and the exhaust pipe is fitted with an oil separator on the exhaust line before it goes into the heating system. Six large Power's traps drain all the steam lines and manifolds and discharge the water of condensation into a Cochrane feed water heater of 1000 horse power capacity. The vacuum pumps also discharge into this system. The exhaust steam from the engines besides heating the buildings is used for the dye house, tubs, drying rooms and finishing department, the condensation of which is returned to the heater. The steam and exhaust pipes throughout are covered with Nonpareil Cork.

The switchboard, which is situated at one end of the engine room, contains the instruments for the alternating and direct current systems. It is made of Rutland blue marble 2″ thick and consists of 4 generator panels and 3 feeder panels for the direct current machines, one of the feeder panels being for power and two for the lighting circuits. The instruments on the direct current switchboard consist of Weston ammeters and voltmeters of the flush type, I. T. E. circuit breakers and Wurt rheostats. The alternating current switchboard consists of two generator panels and one power panel, on which are placed Westinghouse voltmeters, ammeters, wattmeters and synchronouscope. The engine room is ventilated with a direct-driven exhaust fan placed at the top of one end of the room.

A feature of this plant is the oil house, which is a separate building from the engine room. In this room are kept all the necessary oils and waste required throughout the plant. It is 11 feet long by 18 feet wide. It contains 5 tanks of 300 gallons capacity each and they are so arranged that the tops of the tanks are about on a level with the driveway, so that when the barrel is delivered, it is rolled along skids to the proper tank where it is emptied into each tank through a strainer. The tanks contain crank-case oil, cylinder oil, engine oil, boiler oil and turbine oil. The only oil of any quantity in the engine room is in the three Cross oil filters through which the oil is filtered.

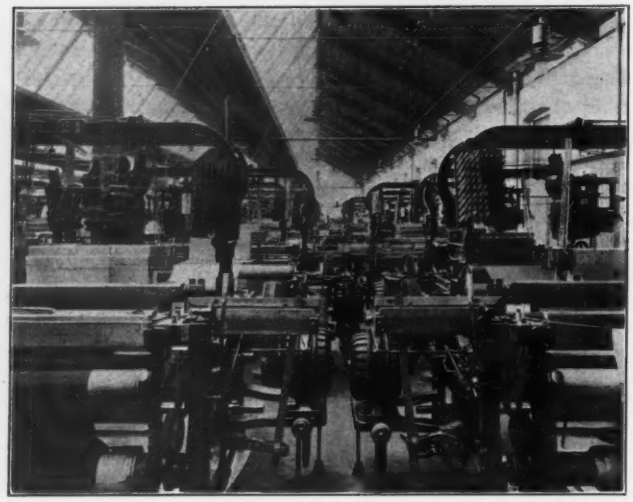
The fire pump house contains one Barr Underwriters' pump 18″ x 10″ x 12″. Steam is kept on the pump at all times and it has a capacity of 1000 gallons per minute when running at 60 strokes per minute. It will generate 100 pounds pressure when pumping through four 1⅛ inch nozzles. Eight hose houses in various parts of the grounds are connected to the fire pump, each having all the necessary equipment. Besides the fire pump there is an automatic sprinkler system with electric alarms for each building. The fire pump is connected to a reservoir having a capacity of 100,000 gallons, which is constantly kept filled and is prevented from freezing in the winter by coils of pipes through which hot water circulates. The service pipes and sprinkler system are connected to four tanks of 1000 gallons capacity each, located at each end of the building and supply artesian well water throughout the mill.

The feature that makes this mill the most unique of its kind in the world is its different electrical drives. There are upwards of 700 motors in the mill, about 400 being direct-cur-

Group of Winding Frames, showing each Machine directly connected with 0.1 H. P. Direct Current Motor, with special control.

rent motors and the remainder alternating-current motors. These motors vary in size from 0.1 horse power to 6 horse power. The accompanying illustrations will show a number of these motor-driven applications. On the fourth floor of the main building are located the warping machines and beaming machines. The warping machines are direct-connected through

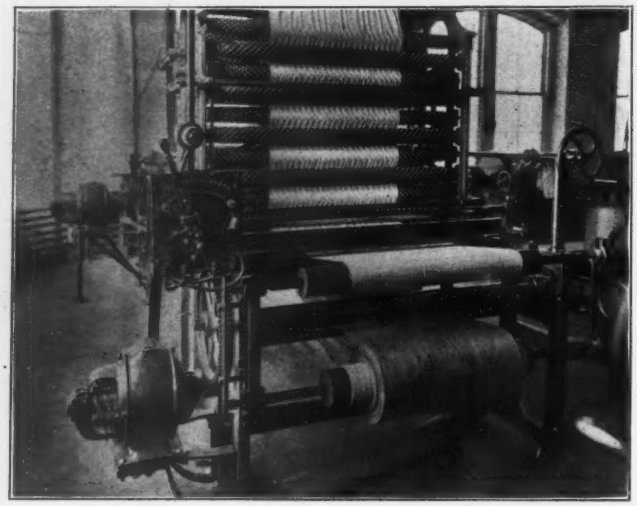
gears to 0.1 horse power motors and the beamers are connected to 1¼ horse power motors. On the third floor, the winding machines are connected to 0.1 horse power motors, the doublers to ¼ horse power motors and the tubing machines, which are run in pairs, are connected to 1¼ horse power and ⅝ horse



A Row of Looms in the Weave Shed, which contains 319 Looms directly connected to one-half H. P. Alternating Current Motors.

power motors, all the above machines being of the Western Electric type except the latter, which are Crocker-Wheeler motors. The second floor contains the winding, doubling, quilling and copping machines. The quilling machines require 1¼ horse power motors and copping machines have 2½ Electro-Dynamic motors geared to them. The heaviest motors are used in the finishing department for the heavy machinery.

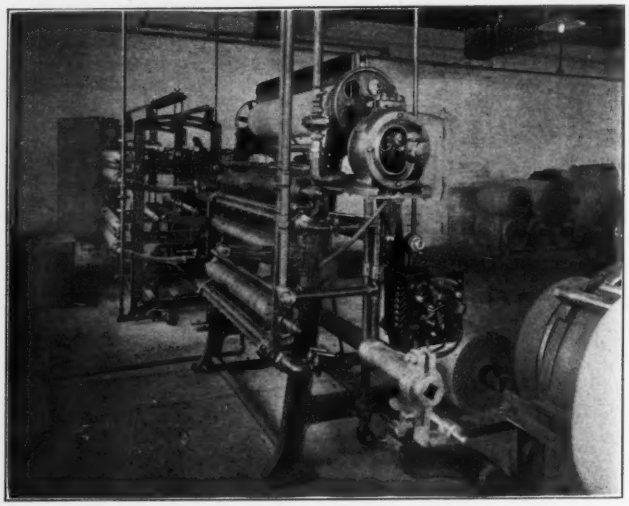
Not only are these motor applications of special design, but all the small machines, such as the winders, warpers and doublers have on them the comulative compound motor and series short circuit snap switch which is controlled by a special key. When the direct-connected motor-driven machines were



Breaking Machine geared to 5-8th H. P. Motor with reversible controller.

first introduced, it was found that the operators, most of whom are girls, would run the motor much faster than certain grades and type of work would allow. This was a constant source of annoyance to the foremen in charge of the mill. To overcome this difficulty, the arrangement shown in sketch was introduced. The motor is compound wound and admits of three speeds. The lowest speed is obtained when the motor is run as a compound motor, the next speed is obtained by short-circuiting one-half of the series winding and the fastest speed is obtained by running the motor as a shunt motor with the series field cut out. The switch which does this is fitted with a special key, which is regulated by the foreman according to the work it is to perform and cannot be changed except by him. It gives a very satisfactory and economical speed regulation. On the winding machines the speeds obtained are 1800, 1400 and 1000 revolutions; on the warpers, 975, 875 and 750 revolutions per minute and on the doublers, 925, 800 and 750 revolutions. On all the other larger direct-current motors, the Cutter-Hammer regulator and reversible controllers are used.

The only part of the plant where the alternating current is applied is in the loom room. This room contains 319 looms, to each of which is directly connected a ½ horse power, type C, alternating-current Westinghouse motor. These machines are three phase, 220 volt, 25 cycle, 4 pole type and run at 660 revolutions per minute, controlled by a three-point switch. With these machines no speed regulation is required, the



Singeing Machine, showing 5-8th. H. P. Motor and reversible controller.

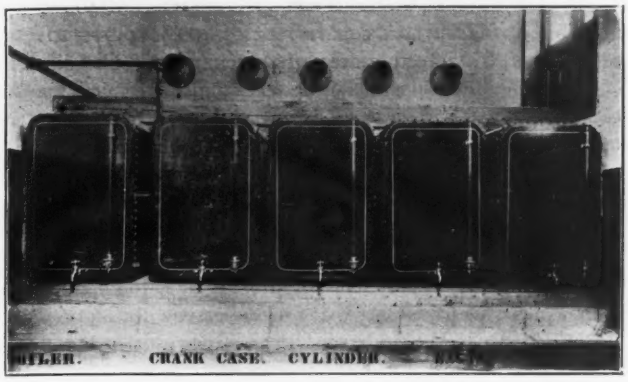
motors of which are always running, the loom being thrown in or out of gear by means of a clutch.

Another feature of this plant is the thoroughness of its artificial lighting system. The plant by night rivals in brilliancy the light of the noon-day sun. To accomplish this perfect illumination 400 incandescent arc lamps are judiciously distributed. Each lamp consumes 5 amperes at 115 volts, the arcs of which are enclosed. These lamps are so placed and the illumination is so full that shadows inside the buildings are unknown. The 500 or more incandescent lamps are used in the offices, stairways, etc. The wiring for the lighting circuits is all done on cleats with Edison plug cut outs on each circuit. So that none of the wires are in the way, the power circuits are run under the flooring on which the machines are located. All lines are run to switches through loricated iron conduits connected to iron switch boxes attached to the machines, Perkins' indicating snap switches being used throughout.

The building contains five elevators of the Plunger type, operated by a Warren pump 14" x 8½" x 12", which maintains

a pressure of 140 pounds on the pressure tank, and two electric hoists each directly connected to a 3 horse power Electro-Dynamic motor.

All parts of the plants are connected by means of the Stromberg-Carlson central energy telephone system of 25 stations.



A Model Oil House.

The operator's desk is located in the main office and is equipped with visual line signals and electric light cleaning-out signals and pilot lamps. For operating this system, two sets of storage batteries of 10 cells each are used, one set being charged while the other set is in use. A separate telephone system consisting of 6 Ness intercommunicating telephones connects the superintendent's office, main office, assistant-superintendent's, watchman's, engine room and electrical department.

The buildings were designed by Mr. Edward Collins, Jr., Superintendent of the Sauquoit Silk Mills, who also supervised their erection as well as the erection of most of the machinery.

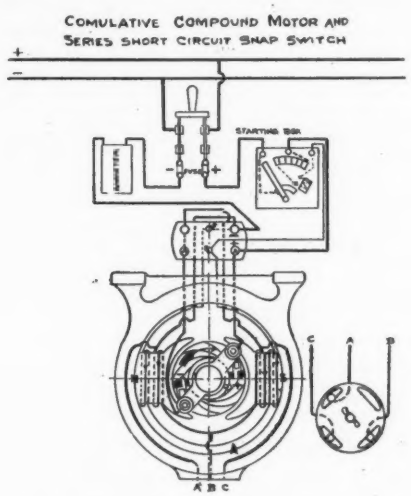


Diagram of Connections of the Special Motors and Switch.

Too much credit cannot be given to Mr. Lewis G. Schlehner, the chief engineer of the plant, who designed and thought out many of the arrangements by means of which the application of the motors was made possible. To him, also, belongs the credit of having designed the above-mentioned speed regulation of the small motors. When it is considered that this mill is the pioneer in this line and when it is remembered that the opposition encountered on all sides was almost insurmountable, the success of the plant is remarkable. We are indebted to Mr. Schlehner for much of the data found in this article.

Chimneys for Boiler Plants.

By R. T. Strohm.

In order that there shall be efficient combustion in the furnace of a steam boiler, it is necessary to have a thorough mingling of air with the combustible solids on the grate and the inflammable gases above the grate. This flow of air must be maintained, in order to give continuous action to the furnace. However, the bed of coal offers no little resistance to the passage of these air currents, and this resistance increases as the size of the coal becomes smaller, giving a more compact mass on the grate. Now, it requires force to produce motion, no matter whether the body moved consists of solid, liquid or gaseous matter. Consequently, where an uninterrupted air current is maintained through a boiler grate, we may naturally expect to find a force propelling this current.

Such is indeed the case. The force which accomplishes this work is known as the draft. The draft may be produced in a variety of ways, but these ways may be classed under two general heads; viz., natural draft and mechanical draft. Natural draft is draft produced by the action of the flue gases, through the agency of the chimney alone. Mechanical draft is obtained by means of fans or blowers, either by forcing air up through the grate, or by sucking out the flue gases from the flues and expelling them up the chimney.

When a chimney is to be used to produce natural draft, its design will depend upon several factors. In the first place, it must be of sufficient area to carry off the gases generated by the combustion of the fuel. This is governed by the quality of the fuel and its nature, as well as by the rate of combustion. And in the second place, it must be of sufficient height to produce the necessary draft pressure, this also largely depending upon the fuel.

The draft which a chimney must produce, is the sum of several items, since the force of the draft is utilized in overcoming several distinct resistances. There is the resistance due to the passage of the air through the fuel bed on the grates, which varies according to the compactness of the layer. Then there is the resistance due to the friction of the gases of combustion as they pass among the tubes, or through the flues, of the boiler. And finally there is the resistance due to friction between the gases and the inside of the chimney. But, if the draft were just equal to the sum of these three terms, there would still be no movement of the gases. In other words, the draft pressure must exceed the sum of the three resistances mentioned, the excess force being applied in giving the gases a certain velocity in the chimney.

Since all of the resistances named are variable, it is evident that a formula applicable to any and all cases would be either too complex for ordinary use, or else impossible. However, it is possible to calculate the draft which might be expected when the temperature conditions are known, and this would give a basis upon which to begin. Afterward, allowances for grate friction, flue resistance, chimney resistance, and air leakage could be made, according to previous experience or research on the part of the designer. In general, it requires

from one-half to three-fourths of the force of the draft to overcome the friction of the air through the grate and the fuel.

Hence, first of all, it is desirable to fix upon the height of the chimney required and then to calculate its diameter. The kind of coal used will to a large extent determine the minimum allowable height. The following values have been found to give satisfactory results:

75 feet for free-burning bituminous coal.
100 feet for free-burning bituminous slack.
115 feet for slow-burning bituminous coal.
125 feet for anthracite pea coal.
150 feet for anthracite buckwheat coal.

The above values are for normal conditions of working, and ordinary rates of combustion of the fuel. These rates of combustion are approximately as follows: 12 to 18 pounds per square foot of grate per hour for factory boilers; 10 to 15 pounds for Cornish boilers; 15 to 25 pounds for marine boilers. The quickest rates for anthracite coal, the air being supplied through the grate only, are 15 to 20 pounds; while the quickest rates for bituminous coal, using air admission above the fire, are 20 to 25 pounds.

It will be seen, then, that if at any time the rate of combustion is to be increased, the chimney must be so designed as to carry off the gases properly. As a consequence of this, there have been established several formulas for the relation between the height of the chimney and the rate of combustion. Letting H equal the height of the chimney and W the pounds of coal burned per square foot of grate per hour, we have the following formulas giving the maximum rates of combustion for various coals, with natural draft:

$W = 2\sqrt{H} - 1$ for anthracite when burned under very favorable conditions.

$W = 1.5\sqrt{H} - 1$ for anthracite under ordinary conditions.

$W = 2.25\sqrt{H}$ for the best grades of semianthracite and bituminous coals.

$W = 2\sqrt{H}$ for soft coals of less heating value.

Having determined upon the height of the chimney, the next step is to find its internal diameter. There are two rules for accomplishing this, both of which have been widely used, and the results of which agree closely. The first is to divide the number of pounds of coal burned per hour by twelve times the square root of the height in feet. It is not a difficult matter to determine approximately the coal which will be required per hour. For, the steam consumption of coal each engine may be approximated, as well as that of the pumps. Then, allowing 7 pounds of water per pound of coal, which is low, purposely, and adding ten per cent. for leakage, occasional lots of poor coal, condensation and minor losses, the coal consumption per hour may be easily found. Let us assume a chimney 100 feet high for a plant demanding 2000 pounds of coal per hour. This, divided by twelve times the square root of 100, or 120, gives an area of 16.66 square feet, or a diameter of about 4 feet 7 inches. This formula gives ample results, but it is better to err slightly on the large than on the small side, since an increase in capacity does no harm, while a too small chimney may cost considerable before it is satisfactorily remedied.

The second rule referred to uses the formula $E = \frac{.3 \text{ H. P.}}{\sqrt{H}}$ in which E is the effective area of the chimney in square feet, H. P. the rated horse-power of the boilers and H the height of the chimney in feet. Assuming the same data as in the previous instance, and applying the above formula, the following results are obtained: Reckoning on 7 pounds actual evaporation per pound of coal, the boiler will evaporate $7 \times 2000 = 14000$ pounds of water per hour, which is equivalent to $14000 \div 30 = 467$ horse-power. Then .3 H. P. $= .3 \times 468 = 140$, and this divided by the square root of 100 is $140 \div 10 = 14$ square feet, the effective area of the chimney. The diameter corresponding to this area is 4 feet 3 inches which may be called the effective diameter of the chimney. The actual internal diameter is 4 inches greater than this, so that by adding 4 inches to the effective diameter we obtain an actual diameter of 4 feet 7 inches, which agrees with the other rule.

The reason for adding the four inches to the effective diameter is explained in this way. The gases, in rising through the chimney, are resisted by their friction against the sides of the chimney. This resistance of course lessens the capacity of the chimney. Hence, to make allowance for this, it is assumed that the chimney is lined inside, along its whole length, with a layer of inert gases two inches deep. This practically means that the effective area, or the area available for useful work, is equal to the actual area less the area of a strip two inches wide extending completely around the inner perimeter of the chimney. The width of this strip being subtracted from both ends of the diameter, the effective diameter is four inches less than the actual.

Where the chimney is to be built in the open, on fairly level ground, the area and height are calculated for the duty of the chimney as estimated, and the results will be found satisfactory. However, if there are sharp bluffs, or hills, or high buildings, these may seriously affect the draft conditions, so that it will be found necessary to make allowance for their effect by increasing the height.

Having determined upon the area and the height of the chimney, the next point is to decide what its shape shall be. It may be either square, octagonal, or round, as regards the exterior, while the interior shaft may be either square or circular. As a usual thing, chimneys nowadays are being constructed circular in section, since this gives a strong form, and one which is less affected by wind pressure, than the other shapes. Also, the material required is less. However, to build it properly, radial brick should be used, to give it the proper curvature. The square chimney is used mainly where the height is small. The octagonal chimney with a round inner shaft is a good form, owing to the fact that the eight corners form long webs which extend the full height of the chimney, strengthening and stiffening it. However, specially formed brick are required to obtain the desired shape.

The usual material for square and octagonal chimneys is ordinary red brick. But this cannot be conveniently used for circular chimneys because of the width of the mortar joints at the outer edges of the courses. A form of brick which is growing very popular for circular chimneys is the radial brick. These bricks are curved on both edges, and are made of different degrees of curvature, as well as of varying sizes, to conform to the diminishing radius as the height of the shaft increases. They are perforated with square holes, and they are larger than the ordinary red brick.

The advantages to be gained by the use of a chimney of circular section, built of this brick may be summed up in this

manner. It gives the strongest shape with the least material, as well as maximum internal area with the minimum material. There is less resistance to the flow of gases in a circular shaft than in any other shape of shaft. The wind pressure is about half as great as on a square chimney whose side is equal to the diameter of the round chimney. The chimney is lighter, since the bricks are not solid, thus lessening the cost of foundation work. The bricks are larger, and so the labor of erection is decreased, while at the same time they will withstand more pressure than the solid bricks of the same material and baking and consequently can be used for greater heights where ordinary brick would not stand the compressive strains. The perforations act as insulating air cells, and for ordinary chimney temperatures it is not necessary to line the interior of the shaft. The mortar, also, is also better able to bind the courses together because of these perforations.

The chimney built of ordinary brick must have a lining or inner core of brick, because of the action of the hot flue gases. The temperature of these gases is usually in the neighborhood of 600° F. and consequently the outer shell could not successfully withstand the action of these gases, because of the expansion and contraction. In cases where it is probable that the gases will considerably exceed 600° in temperature, a partial lining of firebrick should be used. This may reach one-third or even one-half of the height of the chimney.

Since the inner core is exposed to the hot gases, and the outer shell to the external air, it is not feasible to connect the two at a point much above the flue entrance. For the inner core will expand and contract to a greater degree than the outer shell. Consequently they must be distinct from each other, yet at the same time they must give a stable structure. To accomplish this double purpose, the outer shell is made with a number of projecting lugs extending inward, toward the central core, a distance almost equal to the width of the space between the inner and outer shells. This allows the two shells to brace each other and yet permits independent longitudinal expansion and contraction. These projecting lugs should be placed in courses not more than eight feet apart.

In order to produce a stable structure, the column is gradually tapered toward the top, giving a broad base, and making it a difficult matter to overthrow the chimney by lateral pressure. The amount of slope or batter is usually 1 inch in 36 on each side. That is, the external diameter contracts 1 inch for each rise of 18 inches. The inner diameter of the central core is uniform throughout, and it is given batter on the outside.

The taper, moreover, is not gradual and continuous throughout the length of each column. Instead, the shaft is divided into a number of sections, each section being uniform throughout its height. This gives the appearance of steps at intervals. The width of each step is usually 4½ inches, since this is the width of one brick and the mortar it requires. In other words, each section is 4½ inches thicker than the section immediately above it.

Of course, the upper layer of masonry cannot be allowed to lie open to the action of the elements, or it would soon disintegrate and begin to fall off, piece by piece. Accordingly a cap is always placed on the top of the chimney, this cap being either a heavy course of stonework, or an iron casting. It is also necessary to protect the structure against lightning, and this is done by the use of a lightning rod.

Thus far brick chimneys alone have been mentioned. There is another class, however, which is largely used, and this is the steel chimney. It is a long cylindrical column, built of numerous sections which are firmly riveted together, the base being flared out in order to give the necessary stability. The lowest or bottom plate is fastened to cast-iron bed plates to which are bolted steel rods extending down into a mass of concrete and masonry beneath the chimney and forming its foundation. In order to topple over bodily, the entire mass of masonry would have to be overturned also. It is this which gives the stability of a steel plate chimney.

To furnish a permanent means by which to reach the top of the chimney for the purpose of repairs, it is customary to provide a ladder of iron, extending from base to top, usually placed on the outside. This ladder is held to the chimney by having its supports firmly bedded in the brickwork or riveted to the steel shell. Great care should be taken to make this ladder secure in every way, since the safety of human life may depend upon it. Nor should it be allowed to rust or corrode, so as to weaken it. There are numerous iron paints which are effective in resisting corrosion due to the elements, and all exposed steel and iron work should be given a protective covering. To prevent internal corrosion, the steel stack should be lined for at least half its length with firebrick, though corrosion has been found in fully lined steel chimneys.

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Engineering in Japan.

That the modern Japanese are determined to keep abreast of the peoples of the Western world is shown not only by their quick mastery of the art of war, but also by their readiness to appropriate all the results of modern scientific discovery. They are now displaying much activity in the utilization of electricity for lighting, power and traction purposes. The Tokyo electric light works have been in operation for a considerable time, and it has become necessary to greatly extend the power house. The plant at present has a capacity of 5050 horse power, and this is being increased by an additional 3600 horse power. This new plant will go into operation during the present month, and work will then be commenced on a further extension, which will ultimately increase the output of the station by 10,000 horse power. Fresh demands for electric power are being made on the Electric Company by the Railway Company, which is operating an extensive system of light railways in Tokyo. In other parts of Japan there is evidence of similar progress, in which the municipalities are taking a prominent part. For instance, one city proposes to develop close upon 10,000 horse power by utilizing the force of the Tama River. This scheme provides for the harnessing of the water at three different places and the erection of an equal number of generating stations. Another instance of activity in the same direction is the completion of the Keohin electric railway. It runs between Shinagawa and Kanagawa, a distance of about twenty miles. The company controlling the line is laying down a power plant which will supply current for working the line, and an average speed of fifty miles an hour is to be maintained.

THE REGULATION OF STEAM ENGINES.

Method of Speed Control. Cut-off and Throttling Engines.

PART IV.

The features that are most desirable with any form of shaft governor are isochronism and stability; that is, not only should the governor parts be in perfect balance with the centrifugal force, but, at the same time, the governor should not have any tendency to race. These two very desirable features are, however, unfortunately antagonistic. The more stable the governor is made, the greater is the change of speed between

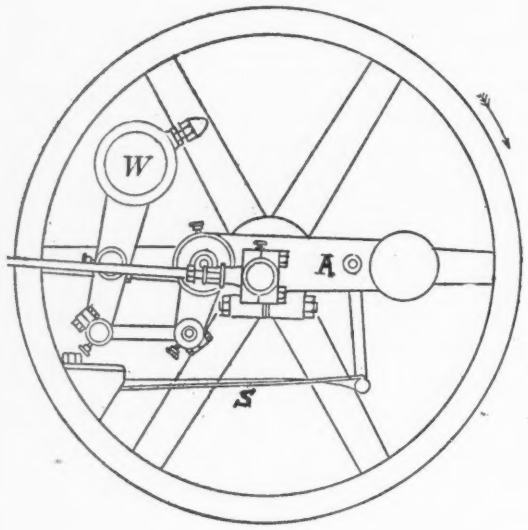

Fig. 25.

light and full loads and the less will it be disturbed by such outside forces as friction, gravity or valve-drag, so that if an engine has a large unbalanced valve, the governor must necessarily have heavy weights and considerable stability. If the governor is adjusted with reference to its synchronism, any disturbing force or change of load would tend to throw the governor balls from their true position, causing them to surge back and forth about their true position. This oscillation is called "hunting" which can usually be dampened down by some resistance such as friction. To check this racing action, oil and air dash pots are used with many forms of governors. They are, however, generally speaking, undesirable, as they increase the friction of the governor and it is this friction, whether in the governor itself or in the valve or valve connections, that it is most desirable to eliminate.

For example: Assume that when the engine is running along smoothly under a steady load, the centrifugal moment of the weight is exactly balanced by the moment of the spring force. If more load is thrown on the engine, the speed grows less. This reduces the centrifugal force and the spring moment, which is now the stronger, should pull the weights in toward the centre of the wheel, thus giving a later cut-off to meet this increase in load; but the friction must first be overcome, and the greater the friction, the greater will be the force required. Usually the only force available is the difference between the force exerted by the spring and the centrifugal force of the weights, so that the speed of the engine must continue to decrease until this difference is great enough to furnish the power required to overcome the friction. Once the weights are in motion, the friction of motion being less than the friction of rest, the resistance is less, and if the force exerted has been great, it is certain that the weights will occupy a position too far in, causing more steam to be admitted to the cylinder than the load requires. The result of this is a constant fluctuation in speed, causing the engine to run at a speed somewhat greater than that for which the governor was designed and, therefore, the dash pot often increases the evil it was intended to avoid. The valve drag has the same effect upon a governor and it has been found by actual experiment that when the same governor was used on engines exactly alike, the one with a heavy unbalanced valve ran faster than the one having a light balanced valve.

Continuing the description of the different forms of shaft governors, Fig. 25 represents a type of governor formerly used on the Reeves engine. It combines the centrifugal and inertia features. The centrifugal weight W, is linked to the inertia weight A, the system being held in equilibrium by a single leaf spring, S. As the speed of the engine increases, the weight W flies out and the inertia arm A moves across the centre of shaft, thereby altering the position of the wrist pin which is mounted on the arm of the inertia weight and acts as a crank pin to reciprocate the valve. At normal speed, the governor weights, W and A, are balanced by the spring S, and any change of speed causes a movement in the arms which results in shifting the valve in the proper direction.

The governor of the Harrisburg engine is shown in Fig. 26. Its governing parts consist of two governor arms on which are mounted both the centrifugal and inertia weights. The large weights are the centrifugal weights and the small ones

Fig. 26.

are moved by inertia. These arms are linked together to the eccentric which is shifted around as the speed increases and they are kept in balance by two coiled springs made with screwed plug connections. The circular ends of the governor arms are cast hollow, so that regulating speed weights may be used, by means of which the speed of the engine can be diminished or increased graduated amounts, without disturbing the

adjustment of the mechanism. The governor is symmetrical on both sides of the shaft, eliminating the resulting effect of gravity action, the friction of the governor being lessened by the use of roller bearings.

The McEwen Governor is illustrated in Fig. 27. The entire governing mechanism consists of a pivoted inertia bar, a spring and an air dash pot. Referring to the figure, CC is the inertia bar which is pivoted upon a roller pin bearing. The

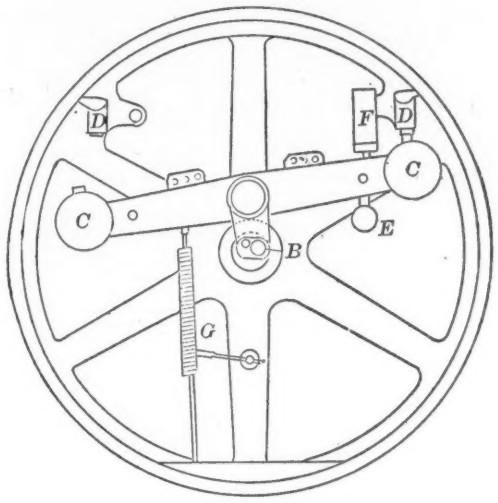

Fig. 27.

inertia bar is symmetrical, with its two ends cast hollow. The end of the bar to which the spring G is attached is weighted, and the motion of the bar is limited by the stops, DD. F is the air dash pot, which consists simply of a cylinder with a loose fitting piston and a connecting rod E, which is bolted to the inertia bar. A pin, B, is attached to an arm of the inertia bar so as to swing across the end of the engine shaft, and the path of motion of this pin is a small circle which varies in radius with the position of the inertia bar. The action of the governor is as follows: Owing to the shape and relation of the various parts of this governor, the weighted end is acted on by centrifugal force tending to swing it backward toward the stop D, at the left side of figure. This tendency to move backward is counterbalanced by the spring G, whose tension is such as to hold the inertia bar in equilibrium at the required speed. The motion of the governor, as shown in the figure, is over from right to left. When the engine is starting up, the position of the governor parts is as shown in cut. In this position the pin B travels in its greatest path, giving the valve its widest opening and latest cut-off. As the speed increases, the centrifugal force, acting on the weighted arm of inertia bar, moves it backward toward left-hand stop D, thereby reducing travel of valve and cutting off steam earlier. When a load is thrown on the engine suddenly, there is an immediate check to the speed of rotation of the governor wheel, while the inertia bar by reason of its momentum, rotates forward sufficiently to increase the travel of the valve and give late enough cut-off to carry the load. The position of rest of the inertia bar depends upon the equilibrium of the centrifugal force and spring G, so that it can be seen that the speed of rotation under any steady running load, depends upon this equilibrium, while the actual movement of the governor parts is effected by the inertia of the weighted parts. In other words, the actual work of governing is done by inertia, while the duty of the centrifugal forces is simply to define the speed at which the engine is to run. The tendency to race is prevented by the dash pot F and the speed of the engine is adjusted by slackening or increasing the tension of spring G. The piston and rod of the dash pot are balanced by a counterweight, which reduces the friction from this cause. The inertia bar is lined with hardened and ground steel bushings resting on roller bearings, so as to decrease the governor friction as much as possible.

A type of governor used by the Erie City Iron Works on their four valve engines is shown in Fig. 28, in which a mass of metal is used to accentuate and quicken the action of the governor, and in which are combined in one mass, the inertia feature and the centrifugal weight. This mass is suspended upon roller bearings, the action of the centrifugal weight, W, and the inertia weight, A, being controlled by a leaf spring. In case the engine, from increase of load, tends to slow down, the inertia of the parts acts as a momentary aid to the governor spring, carrying the weight forward and toward the centre, enlarging the travel of the valve and giving the engine instantly more steam to meet its increased load. Should the load be thrown off, tending to an increase in speed, the inertia weight, A, does not follow the shaft rigidly, but falls back, increasing the effect of the centrifugal weights, W, in their function of shortening the valve travel and cutting off steam earlier in the stroke. The effect of inertia occurs with the variation for which it compensates. The centrifugal force operating upon the weight opposed by a spring is the element of stability and the internal friction is made as small as possible, as the weights

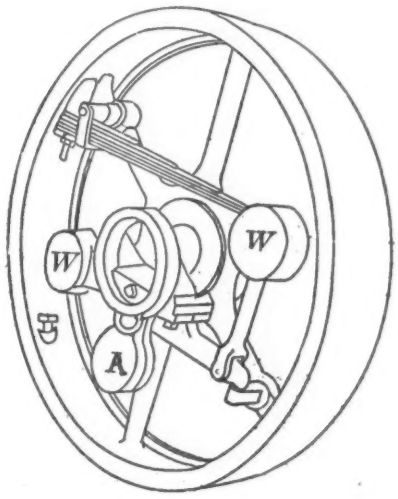

Fig. 28.

can only move to new positions when the difference in centrifugal force amounts to enough to move them. In this form of governor, it will be noticed, a leaf spring is employed. The advantages claimed for it are that, as each leaf can be tempered separately, it does away with that fault in springs of more complicated type, whose form sometimes prevents the uniformity of temper and hence, perfect regulation. In these governors, provision is made so that its action may be reversed, if necessary, and the engine made to run either over or under.

The Horizontal and Vertical Steam Turbine.

By Frank C. Perkins.

During the past decade the development of the steam turbine has been very great, particularly in the direction of electric power generation, both in this country and in Europe. One of the principal reasons for this has been the very high economy in steam consumption of the turbine, while the low cost of the electrical generators, as well as the small space occupied by the steam-turbo-alternator unit, have had considerable to do with this marvelous growth. The horizontal reciprocating engine requires the largest amount of space for a given output, while the vertical reciprocating engine comes next in the point of floor space required. The high power internal combustion gas engines, while requiring practically the same space as reciprocating steam engines are now operated by waste blast furnace gases, and they are therefore, for economical reasons, extensively employed in place of steam engines.

The steam turbines with electrical generators direct connected and on the same base, having horizontal shafts, as the

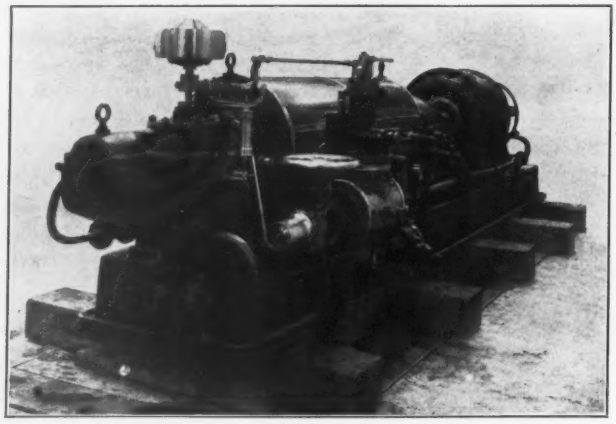

Fig. 1.—150 H. P. Turbine Generator at Berlin, Germany.

Parsons and Rateau types, occupy a very much smaller floor space for a given output than any of the reciprocating types of engines, while the vertical alternator and turbine as constructed by the General Electric Co., at Schnectady, using the Curtiss Steam Turbine as a prime mover requires the smallest area for a given power than any type of steam prime mover as yet constructed.

The accompanying illustration, Fig. 1, shows a steam turbine in the power house at Berlin, Germany, having a capacity of 150 H. P., with a steam pressure of 120 pounds. This steam turbine is directly connected to a dynamo having an output of 100 kilowatts and the steam consumption of this turbo-generator is 27.5 pounds per effective kilowatt hour when operated at full load with a superheat of 374 degrees F. The steam consumption of the turbine when operating at three-quarters load, is 29.7 pounds per kilowatt hour.

As the size of the steam turbine is increased, the efficiency is also increased to a marked degree. The accompanying illustration, Fig. 2, shows a 1000 kilowatt steam turbo-alternator of the Parsons type. This steam turbine develops at normal load 1350 H. P. when operating at a speed of 1500 revolutions per minute. The alternator is a three-phase machine and generates a current of 510 volts pressure and a frequency of 50 cycles per second. Regarding the steam consumption of this 1000 kilowatt unit, it may be stated that when operating at full load with the steam entering the turbine at a pressure of 147 pounds, superheated to 482 degrees F., the steam consumption was 21.1 pounds per effective kilowatt hour. At three-quarters load the steam consumption was

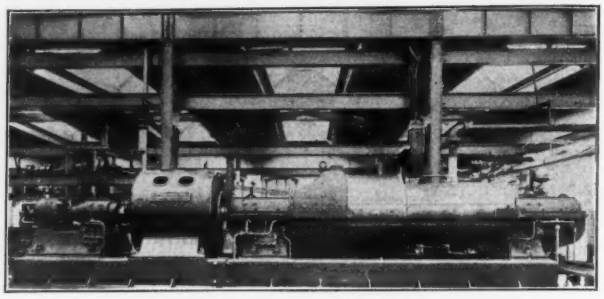

Fig. 2.—1000 K. W. Turbo-Alternator of the Parsons Type.

23.1 pounds per kilowatt hour, the superheat and the pressure of the steam being the same as before on entering the turbine.

The diagram, Fig. 3, shows a Rateau steam turbine, directly coupled to two dynamos and a double turbine of the same construction driving an alternator with direct coupled exciter as built by Sautter, Harle & Co., of Paris, France. This unit has a total length of 16 feet, both dynamos DD, and the turbine, T, being mounted on the same base. The steam enters the turbine through the pipe A, being controlled by the valve at V, while R represents the regulator for controlling the speed of the turbine and direct-current dynamos. The dynamos each supply a continuous current of 220 volts and are operated upon a 440 volt three wire system. This turbine unit has an output of 800 kilowatts, the speed being 1500 revolutions per minute. It weighs 20 tons and measures 23.5 feet in length, the width and height being 7.5 feet and 5.5 feet respectively.

The Curtiss vertical steam turbine, directly coupled to a General electric alternator shown in illustration, Fig. 4, has a capacity of 5000 kilowatts. This machine is directly coupled to a generator of 6 poles, supplying current at a pressure of 9000 volts. The steam turbine, as will be noted, is of the two-stage vertical Curtiss type and operates at a speed of 500 revolutions

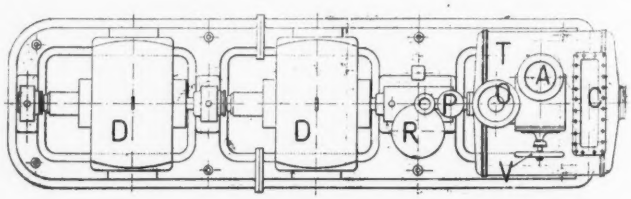

Fig. 3.—Diagram of Rateau Steam Turbine directly coupled to two direct current dynamos.

per minute, the steam consumption being 19.75 pounds per kilowatt hour. The frequency of the 5000 kilowatt alternator of this type is 25 cycles per second, although the frequency may be increased to 60 cycles per second if desired, the number of poles being designed accordingly.

At the electrical power station at Frankfurt-on-the-Main, Germany, noted in illustration, Fig. 5, the Parsons steam tur-

bine and a horizontal reciprocating engine may be easily compared as to floor space occupied, while the size of the alternators, directly coupled to their prime movers is readily recognized. This steam turbo-alternator has a capacity of 3200 kilowatts as a three-phase machine, and 2600 kilowatts as a single-phase generator, the speed being 1360 revolutions per minute. This alternator, it will be noted, has a very small diameter as compared with the large revolving field machine directly coupled to the tandem compound horizontal engine next to it. It supplies a current of 3000 volts pressure with a frequency of 45.3 cycles per second. It was recently tested and when carrying a load of 2995 kilowatts, it was found to have a consumption of 14.74 pounds per kilowatt hour, the steam pressure being 155 pounds and the superheat 598 degrees F. At a load of 2518 kilowatts with the steam pressure 188 pounds and the superheat 560 degrees F., the steam consumption was 15.6 pounds per kilowatt hour, while with a load of 1945 kilo-

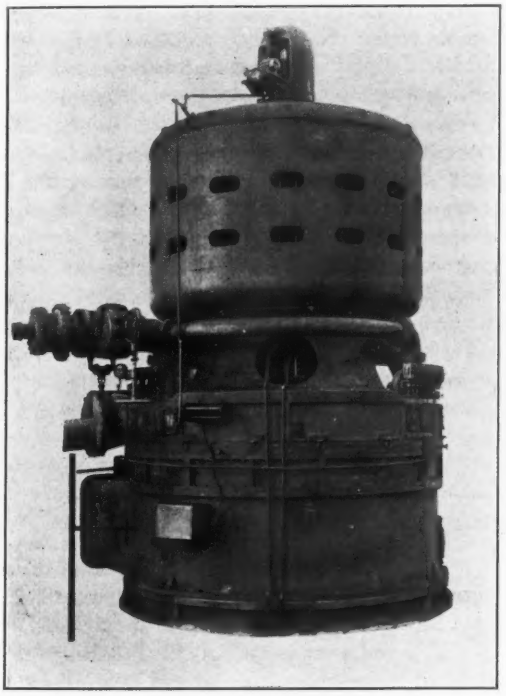

Fig. 4.—5000 K. W. Curtis two stage vertical Turbo-Alternator.

watts, the superheat being 570 degrees F. and the pressure 180 pounds, the steam consumption was found to be 15.8 pounds per kilowatt hour. This steam consumption last mentioned was the guaranteed consumption for an output of 2600 kilowatts with a superheat of 575 degrees F. and a pressure of 188 pounds. It will thus be noted that the efficiency of this steam-turbo-alternator must be considered very satisfactory, the lowest steam consumption of the 4000 H. P. turbine being 14.74 pounds per kilowatt hour with a load of approximately 3000 kilowatts on the generator.

The steam turbine is very economical even when operating without superheated steam and in comparatively small sizes, although the greatest economy is, of course, obtained with high powers and highly superheated steam. The small unit of only 300 kilowatts, shown in Fig. 6, of the interior of the power house at Neuchatel, has a steam consumption of 24.8 pounds per kilowatt hour when operating at full load, the steam turbine developing 450 H. P. with a steam pressure of 175 pounds. This turbo-generator has a steam consumption of 27.7 pounds per kilowatt hour when operating at one-half load. The speed

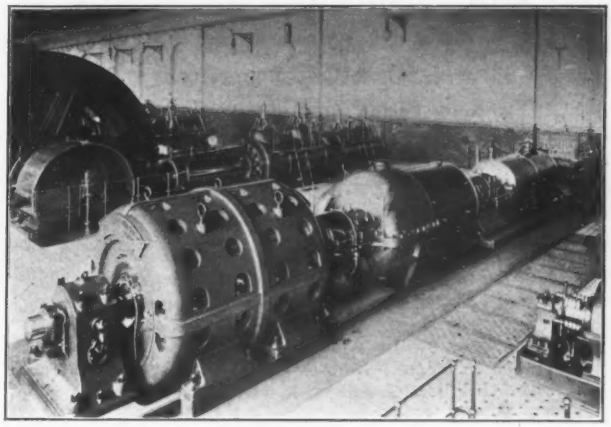

Fig. 5.—3200 K. W. Turbo-Alternator in power house at Frankfurt, Germany.

of the turbine is 3000 revolutions per minute, and the dynamo, which is a direct current machine of special construction, supplies a continuous current having a pressure of 600 volts. It may be interesting to note that there are at present, under construction, a large number of steam turbines in America as well as in Europe, ranging in capacity up to 10,000 H. P.; one of the latter size being built at Baden, Switzerland. Several 5000 kilowatt Parsons steam turbines are being constructed for the new Carville power station at Newcastle-on-the-Tyne in England and a large number of the Westinghouse-Parsons system and the Curtiss-General Electric system are under way for large lighting and railway power plants in this country and abroad.

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Horse Power of Belting.

A simple rule for ascertaining transmitting power of belting, without first computing speed per minute that it travels,

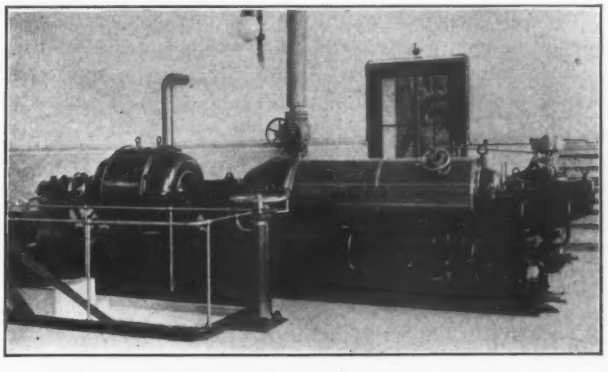

Fig. 6.—300 K. W. Direct Current Turbo-Generator at Neuchatel, Switzerland.

is as follows: Multiply diameter of pulley in inches by its number of revolutions per minute, and this product by the width of belt in inches; divide this product by 3300 for single belting, or by 2100 for double belting, and the quotient will be the amount of horse power that can be safely transmitted.

The Practical Engineer

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The Mud Drum and the Dome. With the advent of higher steam pressures and more intelligent design, the construction of steam boilers has changed in many particulars. One of the most noticeable of these changes is the omission of the mud drum and the steam dome from the later designs. There are good reasons why this should be the case. The mud drum as originally attached to steam boilers consisted of a cast-iron cylinder connected to the main shell at the bottom and near the rear. Its purpose was to form a settling chamber in which all sediment might collect and from which it could be drawn or blown out at intervals. Being of cast-iron, the tensile strength of which is low, it must be made of considerable thickness when intended to carry great pressures, which makes it a bulky, heavy, inconvenient attachment. Furthermore, recent years have developed other and better ways of getting rid of scale and sediment in steam boilers, in the shape of feedwater purifiers and scale solvents, so that the day of the mud drum attachment is passing rapidly.

The steam dome is supposed to effect a drying of the steam and also add to the steam space of the boiler. Both of these purposes it certainly performs, so that it cannot be objected to upon the grounds of inefficient service. In the first place, it removes the outlet of the steam to a greater distance from the water surface, and consequently there is less chance of carrying water over to the engine when the boiler primes slightly. Being of comparatively large cross-section, the velocity of the steam passing through it on the way to the outlet is comparatively slow. This gives the moisture particles entrained with the steam an opportunity to fall out of the steam by mere action of gravity. However, there are other and better ways of securing the same result. The dry pipe is just as useful in obtaining dry steam as is the dome. It is merely a perforated pipe attached to the outlet, but lying wholly within the boiler. The areas of the perforations when taken together are considerably greater than that of the steam main leading from the boiler. The dry pipe is usually placed so as to extend along the upper part of the steam space and parallel to the longitudinal axis of the boiler shell. It thus draws steam from a large portion of the steam space.

Its main advantage over the dome, however, lies in the fact that its attachment to the boiler does not weaken the shell to any appreciable extent. In order to attach a dome, the shell of the boiler beneath the dome is cut away, thus removing a large amount of solid plate, making the boiler considerably weaker under the transverse strains set up, and also permitting greater distortion.

A dome is not essential to the proper working or construction of a steam boiler. Naturally, there must be a steam reservoir, in which a supply of steam may be stored. But if the water and steam spaces are properly proportioned by the designer, there will be ample steam reservoir without using a dome, and without danger of priming. The demand for dry steam and a steam space of considerable size is due largely to the requirements of steam engines which derive their supply of energy from the boiler. However, if a steam reservoir is a necessity, it is much better to add it to the steam main near the engine than at the boiler, for it then allows the realization of a higher initial pressure in the cylinder, with less danger of wire-drawing, especially if the engine runs at a high rotative speed.

The Relative Effect of Losses. The total loss of energy in an electric light station can be obtained by comparing the amount of coal burned with the switchboard output, but it does not tell where these losses occur. Some occur in the dynamo, some in the steam engine and some in the boiler. The loss in the boiler can be obtained by weighing the coal and measuring the water evaporated; the loss in the engine is related to its horse power and the amount of steam used in the cylinder, while the dynamo efficiency is obtained from the electrical output and the indicator card. Going still further, in the direction of the flow of energy, the efficiency of an electric light is the ratio between the watts required and the candle power.

In each of these steps there is a direct loss. Some of these losses in their order are the poor combustion, due to unavoidable causes and unskillful firing, the heat carried off by the flue-gases, the escape of steam and condensation, the leakage of steam through valves and past piston rings, engine friction, dynamo losses, line losses and loss in the lamp.

The most important of these losses is at the lamp end of the line or at the point of application of the electric current, as it is very much more serious here than at the boiler end. The loss of heat by the stack represents simply a waste of coal and wages. The loss in the engine, due to condensation or incomplete expansion, involves besides these, the necessary in-

crease of boiler capacity to supply it. Similarly, the dynamo losses involve, in addition to the factors mentioned, the increased size of the engines and extra attendance necessary; or what amounts to the same thing, without these losses, the same engines and boilers could carry a greater load. In the same way, the loss on the line involves greater generators and the transformer losses involve larger lines. Finally, the losses due to insufficiency in the lamps involve increased boilers, engines, dynamos, lines and transforming devices and further increase the losses in all parts of the system in which the losses increase with the load.

This leads to the conclusion that any percentage loss in the lamps is far more serious than the same percentage loss in the boiler room, the importance of the other losses being dependent upon their position in the transformation of the energy. For instance, if it costs five times as much to produce the energy at the switchboard as it does at the coal pile, due to operating expenses and fixed charges, then any saving at the switchboard will be five times as great as if the same amount of energy was saved at the furnace.

It is for this reason that it is of importance to have lamps of high efficiency, motors of high efficiency and transformers of high efficiency. The efficiency of a motor or transformer is fixed for any given condition and load, but with an electric lamp the efficiency varies. The incandescent lamp rises in candle power during the first few hours of its running and then begins to fall, and this fall is more rapid as the economy of the lamp is greater. As the candle power runs down to about three-quarters of its original value, the fall in candle power becomes smaller until the lamps reach a level at which they burn at a certain percentage of their rated candle power for a very long time, after which they again begin to run down. During all this time, the current consumption of the lamp is the same, so that as the lamp drops in candle power from 16 to 12 or 10, it can be seen that the loss of efficiency is very great, and it is for this reason that the lamps should be run as efficiently as possible and renewed when their efficiency is very much diminished.

The Economical Use of Exhaust Steam.

In any given plant, the question often arises as to whether it is more economical to use the exhaust steam of an engine for heating purposes or whether it is more economical to run the engine condensing and use live steam for heating purposes. The many different opinions upon this subject are as varying as the number of different conditions which are met with in practice. Some engineers advise that a plant should be so designed that wherever possible to obtain the best economic results, everything should be run non-condensing until sufficient exhaust steam at atmospheric pressure is provided for, accomplishing the heating of the boiler feed and other purposes, and the balance of the plant should be run condensing. Others claim that under any circumstances it would be better to run the plant condensing, while still others claim that a plant run non-condensing will always give the best economy when heating by exhaust steam is to be employed.

If an engine is run non-condensing and the ideal condition is attained in which all of the exhaust steam from the engine is used for heating purposes, there is practically no expense that can be charged to the engine, as all the heat generated in the boilers is given up to heat the building and if the engine was shut down, practically as many pounds of coal would be required to heat the building alone as when the engine was running. On the other hand, in summer, all the exhaust heat goes to the atmosphere that was used for heating purposes, so that while in the former case the economy of the engine was a secondary consideration, in the latter case, the less the economy of the engine, the greater will be the number of pounds of coal required to perform a certain duty. In large office buildings, where the lighting load is very small in summer time but comparatively heavy in winter, this reduces the cost of the fuel for the lighting to a very nominal sum and permits the use of engines of low economy without appreciable cost of coal consumption. It has become customary, on this account, to install single cylinder non-condensing engines with a medium boiler pressure in buildings of this kind. If, however, other conditions, such as a large lighting load and small requirements for heating, are met with, an engine having a higher economy should be used.

It is for these reasons that some engineers find that the heat from the steam has cost them nothing; some find that with an increase in power developed there is no increase in expense for coal; others find a saving and some find a loss in the employment of this waste product. What then are the rules governing the use of exhaust steam and when does the loss from its use become equal to the gain to be derived from its use? In the case of a non-condensing engine, it will often depend to a large extent upon the amount of back pressure that must be carried to heat the system. For instance, assume that the same boiler pressure is applied to the engine when exhausting into the heating system, as when exhausting into the air. How much more steam will the engine use to produce the same number of horse power, when it is exhausted into the heating system, or exhausting into the atmosphere? This will depend upon the back pressure on the engine. Generally speaking, it requires about 20 per cent. more extra steam consumption in a steam engine for every 5 pounds that the back pressure is increased above the atmosphere. From this it can be seen when it is economical to use exhaust steam and when it would be better to use live steam; that is, if a back pressure of 5 pounds is required in the exhaust main, it will not pay to use the exhaust, unless the amount of the exhaust exceeds 20 per cent. of the amount of steam normally used by the engine. If only 3 pounds back pressure, then more than 10 per cent. of the exhaust steam should be used for heating, assuming, in each case, that the excess of steam from the exhaust not needed for heat is blown away at that pressure.

If the system of piping is such that the air pump applied to the drip will produce a proper circulation of steam and if the temperature of the exhaust steam is, under the degree of vacuum necessary to produce that circulation, high enough to accomplish the heating, then it will pay to use exhaust steam whenever the amount of steam needed for heating purposes costs more than the running expense of the air pump.

When there are facilities for condensing, the amount that can be saved by condensing must be added to the amount necessary to produce the true cost of the exhaust, except when the air pump can be applied to the heating system. In that case, calculations must be made from absolute zero of pressure instead of the pressure of the atmosphere.

Shop Tests of "Alternator Efficiency."

By J. W. Himmelsbach.

In making an efficiency test of a large alternator after its erection in the shop, it is not often practicable, and mostly impossible to load the machine directly, measuring the input and output, as it means too great an expense of power and apparatus.

TEST OF 550 K. W. ALTERNATOR For Iron-Windage and Friction.

Data of driver—75 K. W. Motor			Data of Alternator.		
Armature Volts	Armature Amperes	Field Current	Amature Volts	Field Current	Iron Windage and Friction -K. W.
167	45.0	1.13	85	0	5.21
167	51.5	"	3300	13.0	6.30
170	69.0	"	4900	20.2	9.42
169	92.5	"	7100	30.2	13.32
169	119.5	"	9200	40.5	19.70
169	146.0	"	10980	51.2	22.38
165	175.0	"	12020	61.0	26.60
169	195.0	"	13080	70.0	30.65
168	217.0	"	13750	79.5	34.12
169	232.0	"	14500	91.1	39.90

Free motor losses at normal speed 2.3 K. W.

The most usual method for measuring the efficiency of a machine, which might be called a negative method, is that of measuring the losses directly, which is comparatively an easy operation.

The losses in an alternator may be divided roughly into three parts, as follows: (1) Losses in the iron core, consisting of hysteresis and eddy current losses. (2) Losses in the copper. (3) Windage of the machine, and the friction loss in the bearings. Of these three, the iron, windage and friction losses are the most difficult to obtain.

The determination of "Iron, Windage and Friction" may all be determined at the same time, and with the same "set-up," of apparatus. The total iron, windage and friction may be determined by measuring the power necessary to drive the alternator at full speed and under full load excitation and then subtracting the power consumed by the prime-mover running at the same speed and under the same conditions as it did during the test. The question now comes up, which is the most satisfactory machine to be used for a prime-mover? A direct-current motor is undoubtedly the most satisfactory, as the measurements are comparatively easy to make, and you are

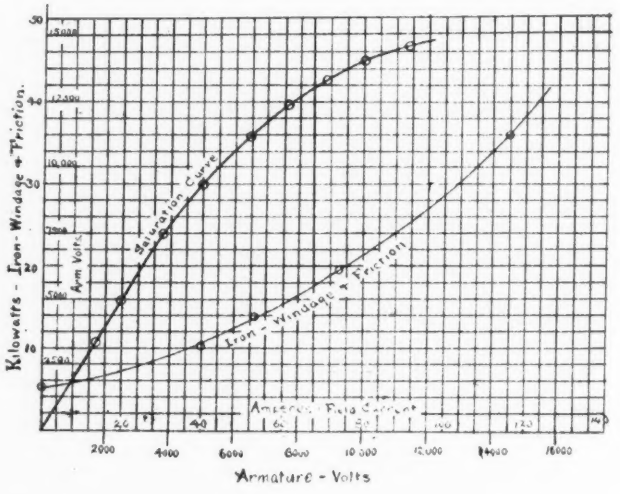
EFFICIENCY TEST OF 550 K. W. ALTERNATOR.

Per cent. Load.	I2R Loss Armature	I2R Loss Field	Iron Windage and Friction	Total Losses	Per cent. Efficiency
¼	.258	3.791	23.4	27.46	83.0
½	1 045	3.817	23.7	28.56	88.7
¾	2.352	3.908	24.2	30.46	92.9
Full	4.181	4.120	25.1	33.40	94.3
1¼	6.537	4.750	26.2	37.48	94.8

able to hold all the conditions constant. A motor whose capacity is about 15 per cent. above the full-load which will be put upon it, will give the most satisfactory readings. In using a motor for a prime-mover, there are several corrections to be made, if the most accurate results are desired. The following losses are to be corrected: in armature, in the brushes, and the iron loss of the motor. The losses in the brushes may be eliminated by measuring the voltage applied to the motor on a pair of insulated brushes, which will carry only the current consumed in the voltmeter, which may be assumed to be a negligible quantity. The iron-loss in the motor may be eliminated by running the motor at a constant field current, controlling the speed by means of the voltage applied, the iron loss there being cancelled from each reading. The loss in the armature, can be calculated, for any load desired, by measuring the resistance of the armature and subtracting the calculated value from each reading.

Provision should be made for holding an absolutely constant speed, by varying the voltage applied to the motor, and also for holding the field current of the motor absolutely steady. Under these conditions the test is simplified a great deal. The best method of joining the machines is, of course, to have them direct connected, or joined by a flexible coupling. If neither of these methods is available, connection by a belt is the only way left. If a belt is used, it should be very flexible, and the joints cemented. However, if an endless belt is not available, a joint, as shown in sketch, is preferable, the ends being turned up and then fastened. This joint is used, as it does away to the greatest extent with the "kick" of the ammeter needle every time the joint strikes the pulley.

Having started the set up, it is advisable to run it for some length of time, with the alternator fully excited, and of course

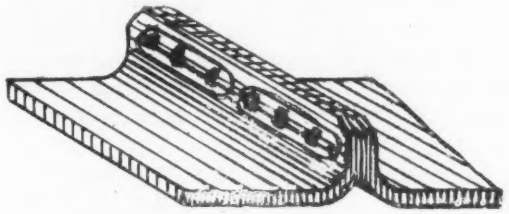


running at normal speed, in order that the friction losses may have reached a constant value, and the core become warm, and also that the value of the losses may have reached the maximum value, in the motor armature, due to rise in temperature.

The motor-field current necessary for the test is then determined, by bringing the machine up to full-load, and then removing the load, to see if the value of motor-field current determined will hold the speed. A reading of the motor armature amperes and volts, with the alternator fully excited will give the iron, windage and friction losses at full-load, the same readings with a field current on the alternator will give the windage and friction losses. Subtracting the power consumed in the motor, when separated mechanically from the alternator, from the above values, will give the net iron, windage and friction losses of the machine in question. If an efficiency curve of the alternator is desired, it will be necessary to measure the iron-loss, at different field currents, the field current read-

ings being those values of current, which will give the armature volts determined by the regulation of the alternator at different loads. This measured iron-loss takes into account, of course, the hysteresis and eddy current losses in the armature core.

The losses in the field and armature may be calculated from the measured resistances and the currents for the fractional loads. The efficiency curve is then plotted from the



values of total loss determined for the different loads.

The question often comes up, which is more desirable in an alternator, high-core-loss and low copper-loss or vice-versa? That question may have the same answer as when it is applied to a transformer, in that it depends entirely on the operative conditions of the machine. If a high efficiency is desired at the full and 125 per cent. loads, a low copper-loss is desirable, and the difference made up by increasing the iron-loss which will not alter the efficiency to any great extent at those percentages of load. On the other hand, if the machine is operated at the fractional loads, the core-loss must necessarily be as low as possible to hold the efficiency up to the mark.

The accompanying tables and curves may be taken as an example of an efficiency test made by the above method.

The Gas Engine for Central Station Service.

At a recent meeting of the New York Electrical Society, Mr. R. D. Mershon read a paper on "The Gas Engine for Central Station Service." He gave the results of a complete study of the engineering aspects of the gas engine and to further his research, he visited most of the large gas engine installations and manufactories both here and abroad. The paper outlines the theory of the gas engine, points out the important bearing of compression as affecting the initial temperature, and describes in detail the four-cycle and two-cycle types of engines.

In reference to the subject of governing the gas engine, it is stated that only two methods have been used to any great extent practically. One of these is the method used with the original Otto engine and still much employed, especially with engines of the older type. This method consists in causing the engine to miss one or more working strokes. That is, instead of there being a working stroke in every four there would at light loads be a working stroke in every eight or every twelve, depending upon the load which the engine was carrying. This method of governing has the disadvantage of requiring a heavy fly-wheel, and that even with a heavy fly-wheel there will be considerable variation in speed. It has the advantage, however, of high efficiency at all loads, since whether the load be heavy or light the quality of the mixture and the compression previous to ignition are the same. The irregularity of the speed, however, consequent on this method of operation is such as to render it unsuitable for many kinds of work, especially for the driving of alternators in parallel.

The method usually employed, therefore, in governing gas engines, especially those of large sizes, and for electrical work, is that of varying the amount of mixture admitted to the cylinder at the same time endeavoring to keep its quality constant. With heavy loads when the engine is taking a cylinder full or practically full of explosive mixtures, the mixture can be suited for the compression which takes place, but with lighter loads it is evident that since the cylinder must be full the only way to preserve the quality of the mixture the same or approximately the same will be to endeavor to stratify the contents of the cylinder. That is, to first admit air to the cylinder and then a layer of the mixture, endeavoring to admit the mixture in such a way that it will not mix with the air, or at any rate to only a small extent, and so that at the back end of the cylinder, at least, there shall be a mixture sufficiently rich to properly ignite under the compression which has taken place. Whether or not this stratification actually does take place has been the subject of considerable dispute, but whether this theory be wholly or only partially correct or not correct at all, the fact remains that engines are operated successfully in the manner described. In one engine, at least, that of M. Letombe, the endeavor has been made to secure reliability in the matter of ignition independently of any question of stratification by making the compression higher at light loads, thus not only making the ignition more certain, but also increasing the efficiency of the engine at light loads over what it would be without the increase of compression.

After developing the principles of gas generators, the paper

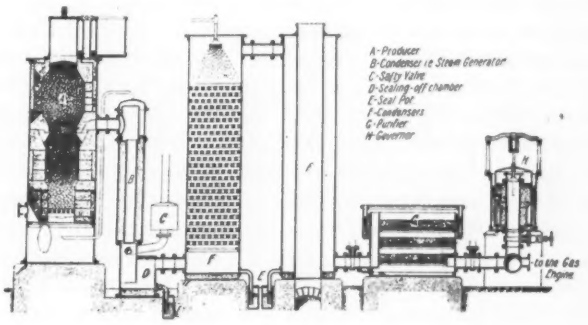


Fig. 1.

describes a particular form, represented in Fig. 1. At the left is shown the generator filled with the fuel from which the gas is to be obtained. This fuel burns at the bottom of the generator by reason of the air admitted to it at that point through the grate bars shown. The air, however, is not admitted by itself but is forced in along with and by means of a steam jet entering the fire box below the grate bars by way of the pipe shown, the steam being supplied by the boiler B. The mixture of air and steam coming in contact with the hot fuel at the grate bars, the air burns a portion of the fuel, thus forming carbonic oxide gas and supplying heat to split up the steam into its elements, the oxygen of the steam combining with a certain proportion of the incandescent carbon to form carbonous oxide. As this combination of carbonic oxide, carbonous oxide and hydrogen passes up through the hot bed of carbon, the carbonic oxide takes up an additional atom of carbon, forming carbonous oxide. There passes over the generator, therefore, by way of

the pipe B, a mixture of hydrogen, carbonous oxide and the nitrogen contained in the air required for the process along with a small proportion of carbonic oxide. The generator is fed as shown by a properly sealed opening at the top, so that it may be charged without interfering with its operation.

After leaving the gas generator the hot gases pass out through the pipe B, heating in their course the water in the boiler as previously mentioned and forming the steam for use in the generator. The gases then pass into the scrubber and the cooling chamber, F, F, in which the gas is cooled and cleaned by a spray of water sent through a checker work or through loosely piled coke. It then passes through the purifier, G which removes such dust as there may remain in it and takes out the superfluous moisture. H is a small gas tank or equalizer for reducing the pulsation in the main occurring at the time when the engine is drawing a supply of gas.

There are many other forms of gas generators, but most of them operate on a principle similar to that above described. This particular generator gives satisfactory results only with anthracite coal or coke. The generators for using bituminous coal require a somewhat different method of construction and operation from that described, because of the fact that with bituminous coal there are given off a number of tar products which must be either all converted into gas or completely washed from the gas before it is used in the engine. If the gas contains any considerable amount of these tar products, there will be a great deal of trouble in the operation of the engine due to the gumming up of the cylinders and valves. The problem of a gas generator for bituminous coal has not in the past received as much attention as that for anthracite coal or coke, and is not now so generally in use. There are, however, a number of bituminous coal gas generators on the market at this time, although most of them depend for their success upon a complete washing of all the tar products from the gas before it is used. There are some generators, however, which may be now considered as having passed the experimental stage in which all or practically all of the products of the coal are converted into gas and the amount of washing or scrubbing required is, therefore, comparatively small. It seems pretty certain that a number of these generators of different makes will shortly be upon the market. Mr. Mershon stated that while in Germany he saw two generators of this kind in operation, one of which, both as to the principle used and as to the results which had been so far abtained, seemed to give every evidence of fulfilling the requirements. In a number of the bituminous generators in which the products of distillation are not all converted into gas there are obtained in the course of purification by-products of sufficient value to enable in some cases a return of about one dollar per ton of coal used over and above the expenses of operating the plant; such a showing as this cannot, however, be made except in plants of considerable size, and in small plants the installation of a by-product plant is not worth considering. The thermal efficiency of these gas generating plants is generally about 80 per cent.; that is, the gas produced by them contains about 80 per cent. of the total calorific power of the coal used.

Mr. Mershon stated that the cost of the gas engine is considerably in excess of that of the steam engine, and as compared with the steam turbine the discrepancy is even greater. There is a point of difference between the steam prime-movers and the gas engine which further exaggerates any relative cost which may be given per horse-power. The steam turbine and steam engine have a certain amount of overload capacity. That is to say, they are capable of operating, though at somewhat impaired efficiency, at loads considerably in excess of their rated output or the output at which they give the best performance. The gas engine, however, has, properly, no overload capacity. Its performance improves up to the point where it cannot carry any further load and at which any further loading causes it to slow down. This is not strictly true for engines of the two-stroke type, which have a slight overload capacity beyond the point of best performance, but this overload capacity does not exceed 20 per cent. of the rating capacity and is probably less. With the four-stroke engine, however, the statement as regards overloads holds.

It is necessary, then, in purchasing gas engines to provide for a rated capacity approximately equal to the overload which will have to be carried at any time, so that a comparison of prices on the basis of the cost per horse-power does not always give a correct idea of the relative costs, because in the case of the gas engine we must provide for a greater total number of rated horse-power. The quoted prices on the gas engines in this country at the present time vary quite surprisingly. Depending on the maker quoting, the prices on a horse-power basis range from 60 per cent. greater than for a steam engine to over twice the steam engine figures. In comparing the gas engine with the steam turbine prices we find a still greater discrepancy. In order to make the comparison it is necessary to add to the cost of the gas engine, the price of a suitable alternator, since the steam turbines are always furnished with the alternator which they drive. If this is done it will result in a cost per kilowatt of output at least twice as great in the case of the gas engine as in the case of the steam turbine, and if the comparison be made on the basis of a suitable overload capacity, the discrepancy will be even greater.

The cost of the gas generating plant for use in connection with the gas engine may be taken as being about twice the cost of the steam boilers necessary for use in connection with a steam prime-motor. This is for a simple gas generating and cleaning plant, without any installation for the production of by-products.

It will be seen ,therefore, that the cost of a gas engine plant, including the necessary gas generator, is considerably in excess of the cost of a steam plant for the same service, especially if the steam prime-movers be turbines. The cost of maintenance and the figure which must be taken for depreciation on such plant is, therefore, correspondingly higher, and the cost of the attendance also greater, since it requires a somewhat better class of men to handle a gas plant. On the other hand, the efficiency of the gas plant is very much better than that of the steam plant, the gas plant requiring for the same service about half the coal required by the steam engine plant and a little more than half that required by the steam turbine plant.

In order to give an idea as to the relative costs of electric power by the three types of plant, and the influence that the cost of fuel has upon the cost of power, figures were presented for a steam engine plant, a steam turbine plant and a gas engine plant, for the same service. In these figures everything is included properly chargeable against the cost of power.

It is assuming in each case that current is to be supplied to a load having a load factor of .5, and that the peak load is 1,500 kw. It is assumed that this load will be carried by four

generators having a rated capacity of 400 kw each, and operating when necessary at 25 per cent. overload. The generators are to be cut in and out of service in such a way that the average efficiency of each unit will be the same as though it ran continuously at 75 per cent. of its rated capacity. The thermal value of the coal is taken as 12,500 B.T.U. per pound, and it is assumed that this coal will evaporate seven pounds of steam when burned under the boilers, and when used in the gas generators will produce gas having a total thermal value of 10,000 B.T.U. It is assumed that a steam pressure of 150 pounds is to be used and that the steam is to be superheated to 150°F. above its normal temperature. Under these conditions the following figures for performance are taken, being such as will be guaranteed by the makers of the various pieces of apparatus: Steam engine, 12 pounds per brake hp-hour; steam turbine, 18 pounds per kw-hour; gas engine, 10,000 B.T.U. per brake hp-hour.

Suitable modifications of these values are made to take care of the fact that the units are to run at 75 per cent. of their rating capacity, and to take care of condensation and auxiliaries in the case of the steam plants. Making use of these

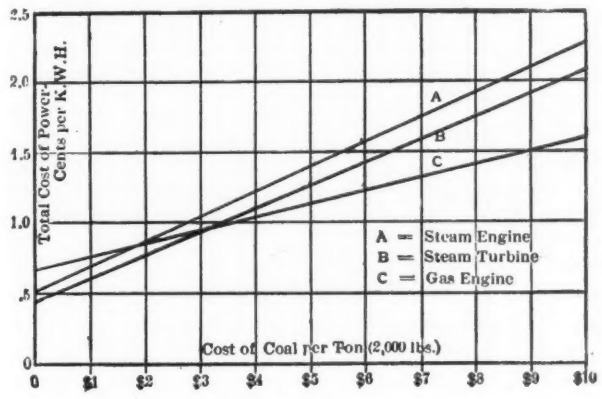


Fig. 2.

figures in connection with the costs necessary for such estimates, there were obtained the results embodied in the curves in Fig. 2. It is to be understood that these curves include everything properly chargeable against the cost of power, including interest, depreciation and renewals on the whole installation and supplies, labor and fuel. The line A shows the cost for a steam engine plant, B for a steam turbine plant, and C for a gas engine plant. The slope of these lines shows in each case the increase in power cost as the cost of the fuel increases. The point at which the line C crosses the other two lines shows the cost of fuel at which the gas engine plant is on a parity with the steam engine plant and the steam turbine, respectively, as regards the total cost of power. These curves give us an idea, therefore, of the cost of fuel at which it would begin to pay, under the present prices for apparatus, to install a gas engine plant rather than a steam plant. As will be seen from the curves, the gas engine plant and the steam engine are at a parity with coal costing about $1.85, while the point of equality with respect to the steam turbine plant is with coal at about $3.00.

It is believed that these curves show the relative performance of such plants under the condition assumed pretty fairly no matter what modifications might be made in the estimates, since while the modifications might change to some extent, the actual value for the cost of power, the relative value will not be much changed by a modification common to all the plants. It should be borne in mind also that these figures are made on the assumption of a load having a load factor of .5, and that for more continuous service the gas engine will make a much better showing. It should also be borne in mind that these estimates are made without reference to any recovery of by-products, and that such recovery would very materially alter the showing made.

An inspection of these curves at the point where the value of the fuel is zero shows very plainly that, if, as it has sometimes been proposed to do, plants be installed at coal mines for the generation of power, a steam turbine and not a gas engine plant should be used unless a plant for the recovery of by-products be made a part of the installation.

The relative values here arrived at will no doubt have to be changed with the progress in the gas engine art. The gas engine equipment will become cheaper as its use becomes more general, and Mr. Mershon considers that this, in connection with the fact that some hard work is being done in the endeavor to produce a gas turbine, permits one to look forward to a time not far off when gas prime-movers of some sort will be installed instead of steam prime-movers.

Hints on Packing Water Gauge Glasses.

In regard to the packing of gauge glasses, there are a number of points to be noticed; first, the glass of the gauge must be of good quality, and the glass must not be too full for the size of the gland. Many glasses are broken from these causes alone. In the second place, the gauge cocks should be perfectly true, otherwise the glass will have too little space for expansion on one side. The packing around the glass must be of good quality. Rubber washers under high pressures above 200 pounds often get soft and blow out. To prevent this it is recommended that they should have a ply of asbestos twine or cord on each side, which protects the rubber.

In screwing up the glands, the glass should be clamped so that it can be moved with the finger and thumb. If it is caught any tighter than this, there will not be room enough for expansion and breakage will result. With the glass left easy, there will be a little leakage when steam is put on, but this will take up as soon as the glass and packing expand. One point to be particularly noted is, that the glass breaks most frequently at the steam end of the gauge cock because the steam is hotter than the water in the glass and causes more expansion. This should be remembered when screwing up the glands, so that the steam end of the glass is left a trifle slacker than the water end, and in every case the steam should be turned on gradually.

Temperature of the Fire.

It has been found by experiment that the color of the fire represents the temperature at which the fuel is burning and it is nearly the same for all kinds of combustibles. When the fire is a just visible red, the temperature is 970 degrees; a full cherry color, 1650 degrees; orange, 2100 degrees; white heat, 2370 degrees; and a dazzling white, 2730 degrees Fahrenheit.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

The Economical Use of Steam.

EDITOR THE PRACTICAL ENGINEER:

The conditions under which steam is used economically are known without doubt by any engineer. As steam is merely the vehicle by which heat energy is conveyed, and as saturated steam of any particular pressure always has a corresponding temperature and always contains a certain number of heat units, it follows that any lowering of temperature or dissipation of heat more than that corresponding with mechanical work performed is wasteful and is to be avoided.

The first source of loss is radiation and while this loss cannot be reduced to zero, it can be made comparatively small by covering radiating surfaces with the best heat non-conducting substances that the market affords.

The next loss lies in the use of steam in the engine itself. It is of course well known that in order to get the greatest possible work out of a given amount of steam, the steam should not be allowed to escape until its pressure is reduced to very nearly 14.7 lbs. per square inch in the case of a non-condensing engine, assuming of course that the exhaust ports are so designed that the back pressure will be reduced to the minimum amount. In order that the terminal pressure may be low, the admission port must close sufficiently early in the stroke to allow the steam to expand down to the desired terminal pressure. From this it follows that for the development of a certain horse-power, the engine must of necessity be larger than in the more wasteful method in which steam at full pressure follows the piston to the end of the stroke. The matter of clearance is likewise very important, as the steam required to fill the clearance spaces is in a certain sense wasted. In using the steam expansively, however, this particular source of loss is somewhat reduced in amount.

It may appear at first sight that there is no need of calling attention to matters that are nothing more than the rudiments of steam engineering. However, such is not the case, for we often find instances in which there seems to be a total disregard of even elementary principles. Such a case as the above came to the writer's attention quite recently and will without doubt prove interesting.

A prominent engineer well known to the writer, and furthermore, a man that prided himself on the efficiency of every piece of apparatus that he owned, became the owner of a steam driven automobile. The machine was used for a couple of seasons and as far as operation and external appearances were concerned it was satisfactory. The boiler, as is customary in such equipments, was quite small and intended to generate steam very rapidly. The engine was of the locomotive type—two cylinders, size $2\frac{1}{2}'' \times 3\frac{1}{2}''$, provided with a link motion and reversing gear; the valves were of the plain slide valve type with $\frac{1}{4}$ inch outside lap, no inside lap.

During the present winter the owner thought he would overhaul the engine and put it in the best possible condition for the coming season. When the interior was examined some interesting facts were made apparent. The clearance at each end of the cylinder was found to be $\frac{3}{8}$ of an inch. The valve construction was such that when cut off took place at $\frac{1}{2}$ stroke, exhaust occurred at the same time. The clearance was reduced to 1-16 inch by riveting some metal disks of the proper diameter and thickness to the inside of the cylinder heads; the early release difficulty was disposed of by making new valves with sufficient inside lap to make release occur at the proper time.

The bearings throughout the entire vehicle, engine and all, were ball bearings, and while it is apparent from this that efficiency was sought, it is wholly inexplicable why such wasteful conditions should be tolerated in the steam engine.

Another matter that should not pass unnoticed in connection with this, is the advantage enjoyed by the proprietor who is fortunate enough to be versed in the principles of engine design. No man can be even a successful operator of a steam engine unless he is familiar with the principles of design and there is no easier nor cheaper way to acquire this knowledge than to subscribe for a good steam journal and read it carefully.

The proprietor-engineer is certainly master of the situation—his steam plant is run economically and efficiently and when he goes forth seeking recreation in his "auto" it is an exceedingly cold day when he has to hire someone to tow him home.

North Adams, Mass. T. H. R.

A Place for Everything.

EDITOR THE PRACTICAL ENGINEER:

I am very fond of visiting brother engineers, and am of an observing nature. I find many engine-rooms topsy-turvy. There seems to be no place for anything; everything is lying in a heap upon a bench in some dark corner or thrown in some large drawer. This is unnecessary as well as very unsightly. I have taken charge of several engine-rooms in such a condition and within a week's time, had things in such shape that you would have thought it would cost quite a sum to put it in such a condition. It, however, did not cost very much and was surely a paying investment. What I did I am sure anybody else can do. The first thing I did was to show the boss how very inconvenient it was to find what I wanted and perhaps in a hurry. He would perhaps look a little sour, but I gave him no time to say a word. I told him that an engine-room was like an office, where it required very little time to do a great amount of business if everything had a place and everything in its place.

If it was in a place where the other employes had tools of their own, I would simply get a few boards surfaced on one side and put up some sort of panel, where I would put wrenches, hammers, chisels, punches, etc. Then I would make a desk for books and papers. I always made the desk with drawers instead of a lid. This was also made of surfaced boards; the drawers were made of cracker boxes; usually four drawers. This was also used for all my packings, as I think it is very important to keep packing free from dust or

grit. This desk was placed in a position where there would be very little chance to accidentally set an oil can or lay any oily tool thereon, usually on the opposite side of the engine-room from tool rack or oil stand.

If everybody about the plant was in the habit of getting tools from the engine-room and not returning to proper place, I put up a locker and kept it locked for awhile, until I had them trained to come to me for tools and be sure they got what was needed.

Then a few rough boards for a rack to put fittings, and with a little lampblack paint marked each pigeon-hole, or used white card board and ink. In this manner I had a place for each and every piece that was in my care. If I wanted a tool, I knew where it was; when I was through using a tool, I put it in its place. When the boss came into the engine-room he seemed pleased and always wanted to know if I needed anything, and if I did he would get it at once. It is easy to keep things in place and tidy if it is done at once and not left until you have more than you can do in the spare time you may have.

Do not try to get along without a broom and a good supply of waste. When through using a tool wipe it with a piece of waste that can be kept handy in a small box at bottom of tool rack. Many employers do not like to furnish waste and I don't blame them in many cases. Make good use of the waste; do not leave it lying everywhere about the plant; have a box for new waste, a smaller one for that that has been used to wipe oil cans or clean oil about engine, and an empty oil can with cover cut out for dirty and wet waste.

Another point in regard to oiling. When using an oil can it is easy to wipe the spout clean with one stroke of clean waste before doing any oiling, and if there is any chance for dust or grit to get on the spout while oiling, wipe off before you fill next cup and you will have smooth bearings and very few hot boxes. When through oiling, wipe can thoroughly and it will always be clean. While oiling it is very easy to wipe many parts of the engine and thus have it always clean and ready to shut down, with very little wiping to do before leaving to go home. I am sure many could make it easy for themselves if they would follow my advice.

Los Angeles, Cal. A. H.

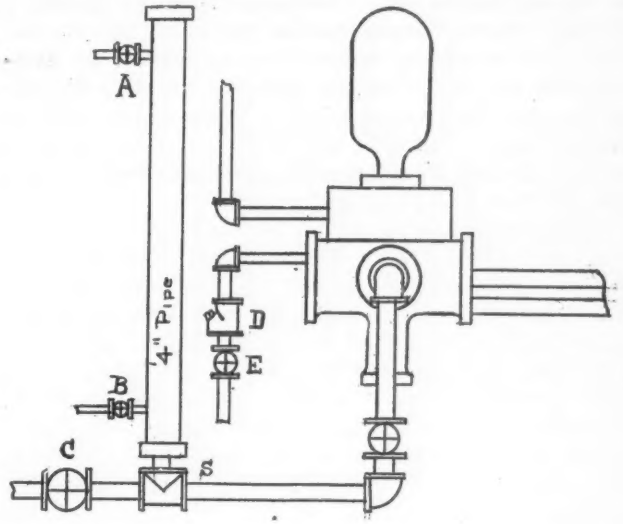
How the Water Hammer Was Stopped.

EDITOR THE PRACTICAL ENGINEER:

Some time ago, I was employed in an electric light steam plant which consisted of three Fitchburg engines of 250 horse power each, Dean condensers, two Sterling boilers of 500 horse power each and two Dean boiler feed pumps. This plant furnished lights for house service as well as for street lighting. The city water main branched off in several places for hotel use, as well as supplying the boilers of the plant. There was a well in this plant that furnished water for the boiler feed part of the night run. The latter part of the run water was taken from the city mains again.

The hotels made many complaints concerning a bad hammering in this water pipe during the last part of the run. As this had occurred for several seasons, we came to the conclusion that the water hammer must stop. Se we began to experiment by cutting the suction pipe at S in the accompanying sketch. We took a 4″ pipe 8 feet long and screwed a cap on each end and tapped the lower cap to take the 2½″ nipple, this being the size of the suction pipe. We next drilled and tapped at each end of the 4″ pipe for a ¼ inch pipe as shown and put a valve on each pipe as at A and B.

Now by opening valve A, air filled the pipe. Valve B was closed and water turned on by opening valve C. This stopped



the hammer for awhile. The valve C would be closed, valve A and B opened, allowing part of the water in the 4″ stand pipe to run out and a new supply of air to enter. The valves A and B were again closed and the valve C opened again for another run. This worked well and the water hammer disappeared until the air escaped from the 4″ stand pipe. This occurred about every five days. We went further with our experimenting and drilled and tapped the water cylinder head for a ¼″ pipe, placing a check valve at D and a globe valve at E. The check opened toward the pump and by closing in the opposite direction allowed no water to escape. By just cracking the globe valve, it allowed enough air to enter the pump to prevent any bad water hammer. This pleased the superintendent very much and he gave us a nice present for our kink.

Cambridge, Mass. W. A. D.

The Way Some Things Are Done.

EDITOR THE PRACTICAL ENGINEER:

As I discussed things as they are carelessly done about the boiler room, in the April number of "The Practical Engineer," I might mention a habit of a fireman I once had, which was a bad one. This fellow was a great one to enter into a conversation whenever the opportunity was offered. If he was firing and some one should drop in, he would walk up to the party, leaving the firedoor open for a number of minutes, allowing the cold air to draw into the furnace and cooling the boiler to a large extent, causing the boiler to suddenly contract. Of course, we are all well aware this was a very wrong thing to do, no matter when or where, for there is nothing that takes the life out of a boiler more rapidly than these extreme changes. The tremendous strains from the expansion and contraction at intervals will surely ruin any boiler used, so I had to issue strong measures to stop this fellow of this habit.

Calling one day on a friend of mine who was an engineer in one of our neighboring towns, I found him in the boiler room using some very strong language. "Well, Bob," I said, "what's the difficulty now?" "Oh, these water glasses are not worth the room they take up, they break as fast as I can put them in." I noticed he would take the wrench he had and screw the packing down very tight on the bottom one and then he turned to the top and did the same. In doing this he was putting a twisting strain on the glass and as soon as the pressure was put on and the packing began to expand and also the glass, something had to give and the glass was sure to break, near the top from the crushing strain or at the middle from the twisting strain. This glass was only in a few minutes when it let go also, and the air was blue for a few seconds again as Bob gave vent to his feelings.

I asked him to let me try my luck and see how I would come out; I might strike the combination. I took a glass, put new rubber washers on and began to insert the glass. After it was in place, I screwed it up at the bottom gently and then turned my attention to the top, clasping the glass in the centre with one hand and with gloves on, screwed the top up with my fingers. Then I turned the steam on and allowed it to warm the glass thoroughly before allowing full pressure on the glass. After turning both valves open wide, everything held without a leak or a break. This glass lasted about a year and Bob had no more trouble after that. I always contend that much unnecessary strength is used on water glasses.

A few days ago a boiler inspector called to make an external inspection of the boilers. Everything went all right until the assistant came to the pop safety valves. The valves were set to blow at 100 pounds pressure and the boilers were carrying 85 pounds. The inspector told the assistant engineer to try them to see if they were all right. Of course, the assistant not having the care of these valves was not familiar with them and he could not make them blow. The assistant engineer reported the case to me, when I returned from my dinner, that he could not make them blow. I asked him what they had done, pushed down on the lever or lifted up on it? He said they pushed down and did not have leverage enough. I enjoyed a good laugh as the assistant said the inspector said they were hard to make blow sometimes when the pressure was a little below what they were set at. What amused me was the inspector not knowing enough to lift up on the lever of these valves, as they belong to the pop safety type.

Abington, Mass. A. T.

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The Steam Loop.

Editor the Practical Engineer:

I wish to have something to say about the steam loop, as Mr. F. H. S. has criticised the Editor either for the purpose of starting a discussion, or, he really does not understand the principle.

If there was no drop of pressure at the separator, that is, if the pressure at the separator was the same as at the boiler, then it would be impossible for the water to rise in the drop leg above the water level in the boiler. Then, if more water was added to the drop leg, the weight of the added water would force the water already in the drop leg into the boiler and hold it there without the aid of a check valve, although there should be a check and stop valve merely for convenience in case of repair to steam loop and one also should be placed at separator.

The working of the loop is explained in the December issue so thoroughly that it would be useless for me to try to do better, although a little different language may make it plainer.

Since there is a difference of pressure of say 6 pounds, the water in the drop leg will rise considerably above the water level of the boiler but the column of mixed steam, water and spray also rises in the riser to take the place of condensed steam and being lighter than the water column in the water leg, rises much higher. The riser then empties its contents into the horizontal, from which it passes into the water leg and into the boiler.

If the steam loop will not work without the check valve, it surely cannot work with it, for it costs something to work the valve.

Elgin, Oregon. J. G. B.

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Fitting Babbitted Brasses to Pin.

Editor the Practical Engineer:

I noticed in the February number of your valued magazine an article on page 23, entitled "Spooling a Pin," which I find very interesting. This same method has been practiced ashore and a great deal of late since the bolt connection has come so much in use. A short time ago I was called to a place where they were having a great deal of trouble with pins heating and throwing the babbitt out of the connections. The engineer was in hot water, so to speak, for one of the large vertical tripples had thrown the babbitt off the lower end no less than three times in a week, and when a crank pin connection on a large engine gets out of order, it generally makes a lot of worry for somebody. The pin that gave the trouble was 10" in diameter and 12" long, with square shoulders. The brasses were made of phosphor bronze and bored out to allow for a suitable babbitt liner. I examined the pin thoroughly, I say thoroughly, for I took a sledge and pounded the crank bells where the pin enters them to see if the pin was loose in either bell. I then closely examined it for any flaws or flat places and I found none; the pin was really in very good shape. I then turned my attention to the quality of the metal used in the liner and it proved very tough and of good quality, so the next thing to do was to see if in the heating there had been any damage done to the brasses. There I found the top brass was warped some. In order to find out whether the brasses were warped or not, I procured a surface plate and placing two 1" square parallels on the plate, I placed the butt bearing surface of the top brass on the parallels, so that the hole was in line with the parallels and I tried to rock the brass on the parallel strips and it rocked easily enough, so that to level it up it required three thicknesses of paper under one corner and two thicknesses under the corner diagonally opposite it. I tried the bottom brass in a like manner, but it was all right. The next thing to do was to have the top brass trued up, that is, have the butt side planed square with the bore of the brass, and so that it would fit the rod also. This done, the mandril was set up and the brasses bolted together with the spools, as is shown in the February issue of "The Practical Engineer."

In the babbitting of the box with a mandril, the brass is made sufficiently small so that the soft metal can be well pened out, and then the brasses are bored out to fit the pin. Care

should be taken in the boring to get the brasses perfectly square on the face plate of the lathe or mill, for any negligence in this line will spoil the fit sooner or later. On a large brass, it is necessary to cut out oil pockets in the clearance space which carry and distribute the oil or grease uniformly over the entire bearing surface of the pin. This pocket is about 1-16" deep by 1¼" wide and is cut out of the brass to within ¼" of each side, thus forming a pocket and reducing the bearing of the brasses. When it is handy, a milling machine is the tool to cut out the clearance with, placing the brasses on the table of the machine as they came bored from the lathe and then mill out the required clearance. If no milling machine is at hand, the necessary clearance will have to be cut out with chisel, which takes a great deal more time.

In the fitting of the brasses in mention, the clearance was milled out and the brasses came to me ready to spot down to the pin. I calipered the pin and brasses and found the latter had been bored a full 1-32" larger than the pin. This allowed for scraping down to a fit and taking out distance pieces if necessary. After carefully "black leading" the pin, putting on a very thin coat, I tried the butt or top brass and it showed up very well, proving to me that the pin had not been worn much, but I was surprised to find so little side play on so large a pin, there being a scant 1-32". I scraped the brass down to a good bearing, making sure to have ample clearance on the sides of the oil pockets, and also to have as much bearing surface as is possible and still allow for take up and wear, on the soft metal boxes. I cut the oil creases in the top brass in the shape of the letter X, having the grooves cross in the centre of the brass where the oil hole entered it. This allowed for good distribution of the oil. I cut very small grooves in the bottom brass and did not bring them together as on the top brass, for it is not so hard to get oil to the bottom half as the top. In getting the brasses to the size of the pin, so as to prevent heating and pounding, it is very important to know when you pull up the nuts on the bolts that the brasses are to a running fit, and in order to do this I use the following means: When I have the brasses ready to connect up to the pin, I take a piece of soft lead wire 1-16" diameter and cross it on the pin, top and bottom, similar to the way the oil grooves are cut, but in such a way that the brass will bear on them at all points. I then pull up the bolts with the spools on, in place of the butt of the rod, as tight as when all connected up. I then slack the bolts, take out the brasses and caliper the thickness of the leads. This proves to me the actual distance that the brasses are running from the pin, called "leading the pin." This distance can be altered to suit the cushion and compression. I have fitted soft metal connections to run as close as No. 27 B. W. G. and I have some leads taken from a 9" pin that caliper .018 of an inch and the engine ran a full season with no trouble from heating.

In this job, I tried the brasses several times and adjusted them to .023 of an inch. These sizes are obtained with micrometer calipers. After I had adjusted the brasses to size, I had a very light cut faced off of both sides of them to increase their side play, and when they were connected up to the rod, I tried them with a short bar or jimmy and found them nice and free at all points. I saw the piston clearance marked on both ends of the guides, so did not speak of it to the man in charge. There was a trial run of eight hours after I repaired those brasses and only the chill off was the report at the end of the trial. I suggested to the engineer to do away with the brass and copper oil pipes leading to the main connections on account of their corroding and filling with verdigris, and putting in wrought iron pipe in their place. I also suggested to him to use photographers' tin for liners, as they would enable him to make finer adjustments, and in regard to the liners I told him that anything over 1-16" should be planed up so as to be uniform in thickness on their entire bearing surface, for uneven liners on a bolt connection are very apt to cause hot pins.

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"MICRO."

Rodney's Troubles.

Or Do We Need a License Law in Michigan?

(Seventh Letter.)

Mistur editur, as i did not reseeve no ansur tu mi last lettur tu u, i begin tu think thet u luked at mi aplekashun fur the job in the lecktrick lite stashun with sum mis feelin', fur the boss or the superintendnt hez neether 1 giv me enny sine az tho thay wud hire me, and i see them almost evry day. i wus in the power hous the uther day and i just luked around a bit and i tell u i seen sum things thet i dont think are rite. 1 thing wus whear the fellar put the kole in fur the fire. he just throde a lot ov slak kole in a big troff and let it run doun on the fire the best way it kud. now with mi thrasher biler i hev tu put the kole in the furniss very keerful elst i put the fire out. nuther thing i didnt see the feller take out enny klinkers frum the fire and when i burn slak kole in mi biler i hev tu kleen out about 4 times a day. them bilers iz a funny kind in the power hous fur thay haint got no fluse and the feller blose the durt and sut off frum the inside ov the biler with a rubber hoze biznus and insteed ov blowen them in frunt, he duz it at the side.

Now mr. editur, i want tu kno whut kind uv a biler it iz thet is kleened out in such a way. a nuther thing i heerd while i wus up thear wus 1 fellar hollered out to the firesman sumthin about sum man gitten kild. his naim wus Wott. any how the feller sed all hands wud hav tu help muve that kasting frum the fraim ov the fiv hundred kill wott generater. and i just tuk it thet it wus a polite way the feller hed ov tellin the firesman thet sum kareles feller hed got a shok thet hed kild him. i did not se them take the ded man away. thay must hev dun the wurk in the nite time. anuther thing i wud like tu no iz, whut part ov the steam, a voltz iz fur. i hurd the greeser tell the firsman thet they hed to inkrees the voltzage, or preshur, az moar lites hed bin put up. iz voltz a nu fangled name fur steam?

i jist found out who the fellar iz whut got the job whut i wus luken fur. i hev not seen him but his name iz oam, or ome, or home sumthen lik thet the firesman sez. he is a gud man on the switch board. the moar i se ov the power hous the moar i git on to there ways ov maken the lecktrik lite and ef thay don't chase me out ile no a hul lot about it in a short while. pleeze ansur mi last lettur rite away, when u git this 1, so i will no u hev got this 1 all rite.

rodney Gumkirk

orkners corners.

Meeshigan

munrow Kounty.

kair my father.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

EDITOR THE PRACTICAL ENGINEER:

Please answer the following questions in the columns of "The Practical Engineer."

(1) What is meant by inches of vacuum in a condensing engine?

(2) Please explain the use and working of the hydraulic ram.

(3) What are the uses of the slotting machine and shaper?

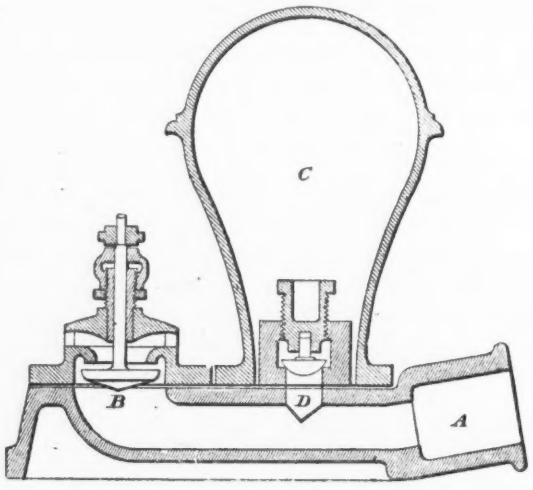
(4) I have heard an argument in regard to heating a room. One man said that he started a fire in the furnace and one room upstairs did not become as warm as the rest did, although the pipes and radiators were all right. Finally, a door was left open in the hall and the room warmed up at once, although no heat could come from the hall. The reply to this was that the reason the room did not warm up was because the cold air could not escape and as soon as the door was opened the cold air escaped and the room became warm. Now, why could the cold air not be warmed even if it could not escape from the room? It seems to me too much like what a man told Benjamin Franklin, that when he opened the shutters of his windows in the morning, it let the darkness out instead of letting the light in.

Silver Creek, N. Y. H. W. B.

(1) The pressure of the atmosphere under normal conditions will support a column of mercury 30 inches high when the pressure above the mercury column is zero, or, in other words, when there is a perfect vacuum. It is, however, difficult and not practical to maintain a perfect vacuum in the condenser of an engine on account of the air and vapor which the condensed steam gives off. The air pump does pump out this condensed water and air to retain a fairly good vacuum, in which surroundings the atmosphere would balance a column of mercury 26, 27 or 28 inches high, whichever the case might be. In other words, by inches of vacuum is meant negative pressure, there being roughly one-half pound pressure for every inch of mercury, so that when one says there are 28 inches of vacuum, he means that there exists in the condenser 14 pounds negative pressure or about one pound pressure above the absolute zero.

(2) A hydraulic ram is a device for raising water for delivery above the level of the source of supply. They are built in several different forms, one of which is shown in the accompanying sketch. A is the supply pipe, B is the pulse valve, C is the air chamber and D is the delivery valve leading to the delivery pipe. Its action is as follows: Suppose the water in the ram to be at rest. When it is in this condition, the pulse valve B is open and the delivery valve D is closed. The water that passes through the delivery pipe, A, begins to flow with a velocity due to the height of the fall of water from the source of supply, through the pulse valve, B, which is open. The pressure of the moving water acts on the bottom of the valve and closes it. At the moment the water ceases to flow, the resultant momentum of the column of water in the delivery pipe causes the ramming stroke which opens the delivery valve, D, forcing the water to the required height. At the same time, the water enters the air chamber, C. The air is first compressed, then brings the column of water to a state of rest and in virtue of its elasticity, causes the water to flow back through A. The moment the backward motion begins, the delivery valve, D, closes and the pulse valve, B, opens again, allowing the water to flow in a forward direction and the operation is repeated.

The efficiency of this machine is about 65 per cent.; that is, one-seventh of the amount of water supplied can be raised a distance of about 5 times as high as the supply head of the ram; or, one-fourteenth of the water supply can be raised and discharged about ten times as high.



Hydraulic Ram.—Section through Centre.

(3) A slotting machine is similar to the shaper in many of its functions. In the shaping machine the tool moves in a horizontal direction, while in a slotting machine the tool moves in a vertical direction. The shaper is in reality a small planing machine and is used for finishing flat surfaces, cutting key-ways, etc. The slotting machine is used especially in places where an irregular contour is to be formed. It is frequently used for forming the inside of a hole and also, as its name implies, for the cutting of key-ways and slots.

(4) Wherever heating is to be done efficiently, there must be a good circulation of air, because air, when it is not in motion, is a good insulator of heat. This applies both to hot air or steam heating, and if the room is not well ventilated, it will be very hard to heat. In the case of the room mentioned, the room could not become warm because the cold air could not be replaced by the warm air, and unless the hot air was forced in under pressure, making the density more, it is impossible to see how the hot air could get in the room. The same thing applies to a radiator in a room where there is no

circulation, and actual experiments have been made with a radiator in closed rooms to show that the efficiency of the radiator was nearly zero when the air in the room remained at rest. The reason for this is that most of the air in a room is heated by convection, so that it is important that the cool air upon entering the room should strike the hot surface to become heated and that there should be an outlet for the already heated air.—[Ed.]

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EDITOR THE PRACTICAL ENGINEER:

Can you inform me, through the columns of your valuable paper, of some method by which one can test a small boiler to know that it is safe?

Brooks, Me. F. K. R.

The means often adopted of testing a boiler, to find out whether it is safe, is by the application of hydraulic pressure. The object of the hydrostatic test is to ascertain if the boiler is capable of sustaining a given pressure and also to test the tightness of the joints. A small hand pump is often used for this purpose and it is generally assumed that if the boiler will stand a pressure of one and one-half times the working pressure, it will be safe to run.

What is known as the hammer test is much used by boiler inspectors, and is frequently preferred to the pressure test. This test consists of tapping the plates with a hand hammer, and from the ringing sound due to the vibrations, and also from the rebound of the hammer, the practical examiner is able to judge of the thickness and soundness of the plates.—[Ed.]

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EDITOR THE PRACTICAL ENGINEER:

Please answer the following questions and oblige a constant reader:

(1) In a throttling engine with a single valve connected to a single eccentric, if I moved the eccentric ahead, what would happen?

(2) What would be the proper way to give a single slide valve the proper lead, to make the valve wider or narrower?

Princeton, Minn. L. G.

(1) When the eccentric is moved ahead it increases the angle of advance. The effect of this is to increase the lead and make admission and cut-off earlier.

(2) If you increase the size of the valve, you increase the lap. Increasing the lap lessens the lead and makes admission later and cut-off earlier. If the valve be made smaller, it decreases the lap, thereby increasing the lead and making admission earlier and cut-off later.—[Ed.]

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EDITOR THE PRACTICAL ENGINEER:

I have a question I would like to have you solve for me. What is the safe, steady working load that a cast-iron column having fixed ends, 14 inches in diameter and 16 feet high can sustain?

River Junction, Mich. F. R.

According to the building laws of Chicago, the safe load upon this column, assuming the column to have a thickness of metal of 1½ inches, will be 224 tons of 2000 pounds each. —[Ed.]

EDITOR THE PRACTICAL ENGINEER:

Please answer the following questions in "The Practical Engineer":

(1) What is lateral motion in steam engineering practice?

(2) How can you determine whether a vertical stationary engine runs over or under?

(3) What is a cam?

(4) What is a tram?

Ash Grove, Mo. C. L.

(1) By lateral motion is meant any side motion to the plane of the parts of the machine spoken of.

(2) A vertical engine is said to run over when the crank crosses the upper centre in a direction away from the observer standing at the front of the engine and it is said to run under when the crank approaches the observer when crossing the top dead point.

(3) A cam is usually a curved plate or groove which communicates motion to some part of the machinery to which it is connected, by the action of its curved edge or groove. The cam generally revolves uniformly around its axis while the rod, which it moves, generally has a reciprocating motion of any nature, which motion may be in a plane inclined at any angle to the axis of rotation.

(4) A tram is a stick or rod which is used to measure the distance between any part of the machine by means of its two points which have a fixed distance between them.—[Ed.]

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EDITOR THE PRACTICAL ENGINEER:

I have charge of a Babcock and Wilcox boiler having 3450 square feet of heating surface, 30 square feet of grate surface, and it uses about 12 gallons of water per minute. I also have charge of a 14⅜" x 36" Greene engine running at 60 revolutions per minute; boiler pressure 80 pounds. The engine is only doing about from 27 to 47 horse power. Another vertical slide valve engine 10⅝" x 17" running at 100 revolutions per minute is not doing over 20 horse power.

(1) What is the nominal and actual horse power of the boiler?

(2) What change would you recommend for economy? The small engine is in one building 90 feet from the shafting in the building the Greene engine is in. The shafts are parallel.

Providence, R. I. W. R. T. W.

(1) The number of square feet of heating surface does not necessarily indicate the horse power of the boiler, as the number of square feet of heating surface per horse power varies with different types of boilers and boilers of the same type. When an average rate of evaporation per square foot of heating surface has been fixed upon by experiment, it is a very convenient way of rating the boiler. In the type of boiler mentioned, from 10 to 12 square feet of heating surface are required for one horse power, so that, taking the smaller number, the nominal horse power of the boiler is found to be 345 H. P.

The actual horse power is obtained by applying the generally accepted standard of evaporation which gives the value of one horse power as the equivalent to an evaporation of 30 pounds of water from a feed water temperature of 100 degrees, to steam at 70 pounds pressure, or 34.5 pounds of water from and at 212 degrees per hour. In the problem mentioned above,

the consumption of the boiler is about 12 gallons per minute or 720 gallons per hour, which is equivalent to 6012 pounds of water per hour. Using the above figure 30, as the factor of evaporation, the actual horse power of the boiler will be about 204.

(2) This is a condition that is often met with in practice. About the best one can do in such cases is to run each engine as economically as possible by setting the valves and regulating the steam pressure so that the full expansion of the steam is taken advantage of, without unduly increasing the initial condensation due to a large range of temperature in the cylinder. —[Ed.]

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EDITOR THE PRACTICAL ENGINEER:

Will you kindly answer me the following questions?

How many gallons of water will be discharged in one minute through a round nozzle 1⅜" diameter, the pressure at the nozzle being 140 pounds per square inch; also what formula do you use for working up the same?

York, Pa. W. H. L.

The theoretical velocity of water issuing from an orifice is the same as that which would be required by a body falling from the height of head of the water above the orifice. That is,

$$V = \sqrt{2gh},$$

in which h = the head of water; g, the acceleration of gravity = 32.2; and V = the velocity in feet per second. In practice, this velocity is not attained owing to various resistances, but the discharge depends on this formula, and the actual amount can be obtained by multiplying the theoretical amount by the coefficient of discharge. The coefficient of discharge of a jet of water is the proportion of the full theoretical discharge which is realized in practice. As a result of many experiments, this coefficient has been found to be 0.61. If, therefore, the area of an opening be multiplied by the theoretical velocity and 61 per cent. of this taken, the actual discharge will be found. This is true for orifices of special design and proportions.

If, instead of an orifice, a short tube or nozzle be used, as in the given case, the coefficient of discharge is about 80 per cent. of the theoretical and with specially designed nozzles, the coefficient may be raised to 97 per cent.

In the above example, let Q = quantity of water flowing through the nozzle per second, A = area of the nozzle in square feet, G = 32.2 and H = height of head in feet, and 0.8 = coefficient of discharge, then,

$$Q = 0.8 \times a\sqrt{2gh} = \frac{0.8 \times 1.484\sqrt{2 \times 32.2 \times 2.3 \times 140}}{144}$$

in which one pound per square inch pressure corresponds to 2.3 feet head. This gives the value of Q as

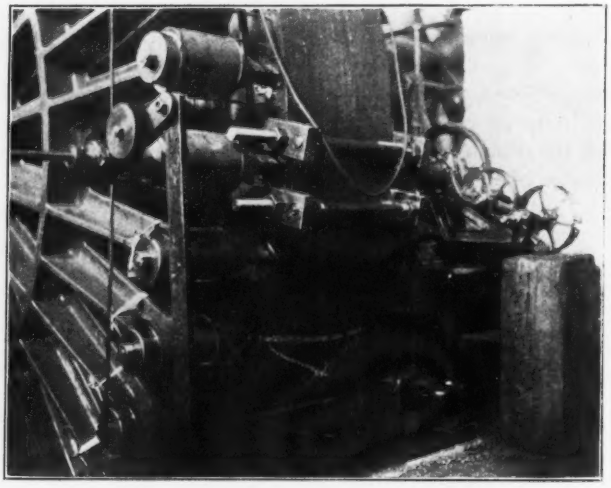
$$Q = 1.19 \text{ cu. ft. per second.}$$
$$= 71.40 \text{ cu. ft. per minute.}$$
$$= 71.40 \times 7.48 = 534 \text{ gallons per minute.}$$

As will be noted, this quantity depends upon the coefficients of discharge assumed in the formula. If the coefficient of discharge is taken as 0.97, then the quantity of water flowing from the nozzle would be 647 gallons per minute.—[Ed.]

An Interesting Dynamo Repair.

H. B. Underwood and Company, of Philadelphia, have just finished an interesting repair to a large Siemens-Halske generator, which is in reality in the nature of an improvement. This generator is one of three 875 K. W. 550 volt machines in the power house at Ogontz, Pa. These generators are direct connected to vertical compound Allis-Corliss condensing engines and are used to generate power for trolley service. These generators have internal fields, the armatures running around them. The armature consists of laminated plates held together and driven by means of a large spider having forty arms. These arms are connected to the armature by means of bolts which not only clamp the laminated core discs together but support them and drive them. The armature coils are then laid over the armature discs, the commutators of these machines being the outside of the revolving armature.

It was found that after the machines had been run for some time, the heat of the commutator and armature heated up the iron discs and the rods so much that it charred the paper insulations which were originally put between them to prevent the eddy current loss. As this paper became charred, it became a good conductor and allowed not only the iron discs to electrically touch each other but also the iron bolts to touch the discs, as there was only a paper insulation between the discs and the iron bolts. The effect of this was to increase the eddy current loss and thus diminish the efficiency of the generator.



Repair to the Armature of 875 K. W. Siemens-Halske Generator

The Union Traction Company, to whom this plant belongs, called on H. B. Underwood and Co. to remedy this. The core discs were all taken off and in the place of the paper, each disc was shellaced and bolted together with the old 1¼ inch bolts. Each bolt was then forced out separately and the hole through the armature discs enlarged from 1 5-16 inches in diameter to 1 9-16 inches in diameter. The accompanying illustration shows the boring bar boring the twenty-seventh hole through the armature. The holes were enlarged with two cuts, it taking on an average 1¼ hours for each cut.

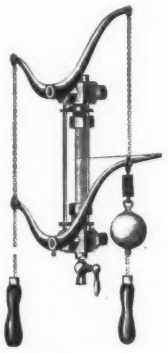
The whole arrangement for doing this work was most ingenious. The boring bar was connected by means of gears to the electric motor which does the driving. On the other end of the boring bar a thread was cut which revolves inside of two gears. These gears run with two other gears, one of

which has one less tooth than the other. The effect of this is that while the boring bar drives the gears, the gears in turn due to the difference in velocity ratio between them, feed the cutter bar, pulling the cutter through rather than pushing them. Great care must be taken, in boring such a long hole as this, not to allow the chips from the cutter to congregate in the hole. To avoid this, the boring bar was made hollow so that the chips could be blown out by compressed air, the diameter of the bar being so proportioned that when the air came through little holes around the cutters, it allowed the chips to be blown out freely. The cutters also had to be very sharp as the armature discs are made of very soft iron. The effect of a dull tool would be to bur over the edges of the laminations, thus aggravating the evil it was intended to prevent.

The finished hole being bored through satisfactorily, a mica sleeve ⅛ inch thick was slipped over the bolt and inserted in the enlarged hole, after which it was bolted tight and the repair completed. After forty of these holes were drilled, the armature coils were put in place and the commutator reassembled, after which the machine was ready to run for the summer season.

The Cunningham Auto-Positive, Self-Closing Water Gauge.

When a gauge glass breaks on a boiler, it is always a source of great annoyance, inconvenience and often dangerous both



to the attendants and the boiler, unless the escaping steam is stopped at once. This is best done automatically, as it requires no attendance and the steam is shut off at once.

It is a well-known fact that the water glass is the weakest point on a boiler and any appliance that will protect that point must necessarily be of value. The accompanying cut shows a device which does this. It is especially adapted for high pressure service, on locomotive boilers and separators, where a man is usually close to the glass when it breaks, on acid tanks, or on gauges in out-of-the-way places which are inaccessible. It is also well adapted to low pressure and house heating boilers, expansion tanks and to boilers that are left over night with no attendant, in which case glasses are liable to break and do great damage before the water or steam can be shut off.

It depends upon the force of gravity for its operation and boiler scale or corrosion does not interfere with it. It admits of being tried at all times by rocking the levers slightly, without disarranging its parts. If the glass cracks enough to let out steam or water, instead of flying into thousands of pieces, the ball is of sufficient weight to pull out the glass and shut off the cocks instantly.

It is made in several sizes and styles by the Standard Gauge Manufacturing Co., of Syracuse, N. Y., and is made of steel for ammonia or acids.

Pressed Steel Shaft Hanger.

A new form of pressed steel shaft hanger has recently been introduced to take the place of the ordinary cast-iron hanger. Cast-iron, at best, is a treacherous metal and in many places a more reliable and rigid hanger is necessary to stand the shocks

and strains which come upon it. The most faithful and reliable metal for this purpose is pressed steel, which is very much stronger than cast-iron, more homogeneous and can be worked in dies and pressed into any shape.

The cuts shown herewith represent the American Pioneer pressed steel shaft hanger, manufactured by the Standard Pressed Steel Company, at Twentieth and Clearfield Sts., Philadelphia. It consists of two pressed steel legs of such a section as to give the maximum rigidity with the minimum weight. These legs are tied together at three points: At the feet, by a corrugated steel tie plate, securely riveted to them to hold them a proper distance apart; in the middle, by a pressed steel brace, corrugated and riveted to each leg; and at the ends, by an arched clamp which can be detached or swung around to one side when removing or inserting the bearing block. Excepting the box, bolts and adjusting screws, the hanger is made entirely out of open hearth steel pressed to shape.

The bearings of this hanger are of new and improved design. In general arrangement they are similar to the regular bearings, having an upper and lower half bearing, an oil pan and oil rings. The improvement lies in the ball and socket arrangement which is four way adjusting. The bearing is first adjusted by the four set screws which hold the outside of the bearing box firmly in place, and any other adjustment is done

automatically by the half bearings in which the shaft runs. As they have perfect freedom between their ball and socket supports, it permits the true alignment of the shaft. The oil pan is cast in the lower half bearing, in which the oil rings

revolve, throwing the oil continually on the shaft. To prevent the oil from running along the shaft, automatic wipers are used.

Besides its reliability and rigidity, another feature of the hanger is its reduced weight and increased strength, it being claimed that while it is fifty per cent. lighter than a cast-iron bearing, it is at the same time two hundred per cent. stronger. Its reduced weight has the usual advantages of being easier handled, easier shipped, with a correspondingly less freight charge and easier to install than the ordinary cast-iron hanger.

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Book Reviews.

My Air-Ships. By Alberto Santos-Dumont. 12 mo., 400 pages. Illustrated with seventy-five photographs and diagrams. Price $1.40. Copyright, The Century Co.

Alberto Santos-Dumont's "My Air-Ships" stands out unique among new publications. It is the simple, direct account of an earnest, gifted man's struggle with the problem of aërial navigation. From his first experiments to his final wonderful successes and victory over the laws of nature, one is taken along with him in such an interesting manner that interest in him and his air-ships never for one instant relaxes. From the first ascension of his dirigible balloon on September 18, 1898, to the winning of the Deutsch prize of $25,000 on October 19, 1901, he encountered many hair-breath escapes in his many daring ascents and terrifying descents. All of this is chronicled in a bright, entertaining and scientific way, in which the principles of the air-ship are thoroughly discussed. There are seventy-five reproductions of photographs and diagrams to add to the explanations of the ten or more dirigible air-ships which he constructed.

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Hendricks' Commercial Register of the United States. One large octavo volume. Cloth, 1300 pp., 10½ x 8. 1903 edition for the year beginning November 1st. Price $6.00. S. E. Hendricks Co., publishers, 76 Elm Street, New York.

This work is a comprehensive register of the professions and trades of the country. It is especially designed for purchasing and mailing purposes and is particularly adapted to the needs of the manufacturers and jobbers of every kind of machine, tool, apparatus, specialty, etc., used in the engineering line. It contains comprehensive lists of the Mechanical, Electrical Hydraulic, Consulting, Heating and Ventilating and other Engineers and Contractors for complete Power Plants, Engine and Boiler Manufacturers, Heater Manufacturers, Steam Fitters, Macinery Dealers, Machinery Manufacturers, Machinists and Founders, Mill Supplies Belting Manufacturers, Packing Manufacturers, Valve Manufacturers, Engineers' Supplies and Steam Specialties of every description. In fact, there appears to be scarcely a material, machine, tool or specialty used in the engineering and kindred lines that is not listed in its pages and the work is arranged and indexed in such a simple and systematic manner that any particular trade or specialty can be found at a glance.

A very valuable and useful feature of this book is the insertion of trade names and descriptive matter of specialties following the names of manufacturers under their respective classifications.

The completeness of the lists of this volume is dependent upon neither subscription nor advertisement, for all firms are classified in it under every variety of their product, free of charge. For this reason alone it is indispensable as a book of reference and invaluable to the buyer and seller. It is by far the best work of its kind that we have seen.

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Compendium of Drawing. Compiled from the Instruction Papers in the Architectural, Mechanical Engineering and Sheet Metal Pattern Courses at Armour Institute of Technology. Two Volumes, 7" x 10"; 900 pages; 1000 illustrations. Price, $8.00. Copyright, 1904.

These two volumes are about as complete, in the thoroughness of details, in the number of subjects taught, and in the description of the various processes involved in making a drawing, as we have yet seen.

As the success of a draftsman depends to a certain extent upon the quality of his instruments and materials, the book first describes these together with their uses. Geometrical constructions are then taken up and then the principles of orthographic projection and their application. We had often hoped that when another book on drawing was published and the theory of orthographic projection developed, it would apply this theory to the third angle instead of the first angle as is always done. It is often confusing to the student to be taught the theory in one angle and its application in another. This, however, in this book, is not so noticeable until the second volume is reached, where many of the drawings described are made in the third angle, and some in the first angle. To one who is not perfectly familiar with a drawing, it is ever a confusing thing to read a drawing in one angle when he is used to drawing it in another.

Of course, the reason for much of this is that some draughting rooms are now using the first angle while the greater majority of them use the third angle, and if in the future either of these planes of projection is definitely adopted in practice, it is to be hoped that the theory will be taught by the

revolution of the planes of projection always in the same direction as in practice.

Other than this, the books have everything to commend them, the chapters on screw threads, gears, cams, belting, machine design and working-shop drawings being especially valuable.

ALLENTOWN CONVENTION.

Some Facts About the City Where the 18th Annual Convention of the A. O. S. E. Will be Held.

Allentown, where on May 9th, many engineers from all over the country will be assembled, is situated on the Lehigh River, about sixty miles north of Philadelphia. It can be reached by the Lehigh Valley Railroad, the Central Railroad of New Jersey, the Philadelphia and Reading, and the Perkiomen Railroad. It can also be reached by trolley from Bethlehem, Easton, Reading, Philadelphia, and other towns. The trip from Philadelphia by trolley can be made for fifty cents through the most beautiful parts of Eastern Pennsylvania in a few hours. The round trip by rail costs $2.53 from Philadelphia.

The convention headquarters will be at Hotel Allen, located at Seventh and Hamilton Sts., opposite Centre Square. All the arrangements are being carried out by Lehigh Council, No. 15, who have appointed their committee of A. P. Dreisbach, A. J. Strauss and Edmund Brader, who report that everything is progressing favorably. A large hall has been selected for the exhibition of machinery and engineers' supplies. The convention committee's headquarters is at 607 Hamilton St.

Among the many interesting features in and around Allentown are the Allentown Water Works, the Adelaide Silk Mill, the American Steel and Wire Works, as well as many shoe factories, brick factories, tobacco factories, etc. It also stands in the heart of the cement industry, it being surrounded by some of the largest cement mills in the world, a visit to any of which would be exceedingly interesting. In 1888, the present water works were established at the Fountain House when two 3,500,000-gallon Knowles pumps were put in and in 1901 the large 8,000,000-gallon Holly pump, a new pump house and boiler plant were added.

The social program, being prepared by Lehigh Council, will do everything to support the reputation of the town for hospitality and those who will be fortunate enough to be there will learn what that term means in the truest sense.

Grand Council Resolutions.

The resolutions adopted by Grand Council, at their last session, at Philadelphia, on March 15, 1904, were as follows:

We, the undersigned committee appointed by the Grand Council at our convention held at Allentown, Pa., March, 1902, for the purpose of disbanding the Grand Council, after all legal complications were settled, do respectfully report:

That after due consideration, your committee recommends that the Grand Council shall adjourn *sine die;* that the present Grand Officers be retained; that the Subordinate Councils shall elect their delegates direct to the Supreme Council; that the Subordinate Councils shall pay their *per capita* tax to the same, as the Supreme Constitution directs; the same to begin this term (first term 1904); and that each and every Subordinate Council be notified by the Grand Corresponding Engineer.

The charter of the Grand Council to be returned to the Supreme Council, and the Supreme Council to issue a new charter to each Subordinate Council free of charge.

FRANKLIN R. MOOR,
FLORIAN J. ARMBRUSTER,
FREDERICK MARKOE,
W. J. COURTNEY,
A. P. DRIESBACH,
H. M. TROUT,

Committee.

Municipal Council.

The officers of Municipal Council, No. 20, A. O. of S. E., recently installed, are as follows: Chief Engineer, Walter Franks; Assistant Engineer, Edward Orrell; Corresponding Engineer, William Johnson; Financial Engineer, William J. McCracken; Treasurer Engineer, Daniel Bunting; Senior Master Mechanic, William J. Durass; Junior Master Mechanic, Edward Harley; Chaplain, Joseph Clark; Trustees, Daniel Bunting, Samuel Black and Edward Harley. Representative to Supreme Council Convention, Daniel Bunting; Alternate Delegate, Edward Hall.

The officers were installed by Grand Deputy Kelly and Grand Corresponding Engineer, Markoe. Besides a very pleasant social evening, there was a very warm debate on "How a Pump Draws Water."

Engineer for Half a Century.

Mr. Joseph McFetridge, of Allentown, Pa., has recently completed a full half a century of service in the Thomas Iron Company's Works, at Hokendauqua, near Allentown, Pa. He is the only living man who has been on the pay rolls of the Company continuously since the erection of the mill in the spring of 1854. He ran the engine that hoisted the stone for the first stack that was erected and when that stack was put in blast he served as blowing engineer. In the summer of 1856, he also ran the first locomotive the Company put in service. He is 70 years old.

These Were Good Friends.

With his back from neck to waist successfully covered with patches of cuticle taken from two friends, Charles Hallock, of Baltimore, Md., an engineer, who was frightfully burned in the large railway power house last November, is now ready to leave the hospital. But for the heroic conduct of these friends in sacrificing their skin, he would have died. It was the largest case of skin grafting ever performed in Baltimore, and attracted the attention of surgeons in all parts of the country. The burned surface covered 18 by 24 inches, over which the new skin has adhered perfectly.

The next convention of the Massachusetts State Association of Stationary Engineers, N. A. S. E., will be held in Lynn, Mass., under the auspices of Massachusetts Council, No. 15, on July 8th and 9th, one month earlier than usual, so as not to conflict with the National Convention. Mr. C. A. Cowles is chairman of the local committee on arrangements.

TRADE NOTES

The Practical Mfg. Co., of Richmond, Indiana, are putting out a Practical Belt Stick that is giving a wonderful amount of satisfaction. It is tubular shaped, making it very convenient to put on belts, and its lasting qualities far exceed any other known article to prevent the belts from slipping, and they may be run very slack also. The Company guarantee this Belt Stick in every respect. Send for a free sample, prices, and what other people say about the Belt Stick.

Mr. W. F. Warden, President and General Manager of The Burt Manufacturing Co., makers of The Cross Oil Filter and The Burt Exhaust Head, Akron, Ohio, sailed for Europe on the steamer Celtic, of the White Star Line, from New York, April 15th.

Mr. Warden goes in the interest of his Company, which has a large foreign trade in all the principal countries of the world; in fact, there is not a place on the globe where lubricating oils are used and steam plants are in evidence that The Burt Manufacturing Co., and their celebrated Cross Oil Filter and Burt Exhaust Head have not been adopted.

Mr. Warden will confine this trip to visiting agents of his Company in England, France, Germany, Belgium, Norway, Sweden, Denmark, Russia, and if time permits he will visit those in Switzerland, Greece, and Spain.

In Mr. Warden's absence, Mr. J. Asa Palmer, Secretary of the Company, will have full direction of its affairs.

Among the many large foreign orders received in the past few days by The Burt Manufacturing Co., is one from their agent at Durban, South Africa, for thirty gross of oil filters, and one from their agent at St. Petersburg, Russia, for oil filters for the Russian Government.

The Burt Manufacturing Co. have gotten out an interesting picture showing a thirty-inch exhaust head that they recently made for the Jones and Laughlin Steel Company, Pittsburg. This exhaust head is ten feet high, nine feet four inches in diameter, and weighs two thousand and seven hundred pounds.

Mr. W. F. Rose, Engineer for the Manhattan Storage and Warehouse Co., 52nd St. and 7th Ave., New York, has just written the following letter to the Standard Steam Specialty Co., of 542 West Broadway, New York:

"I am pleased to state that the 'Utility' Exhaust Muffler, Oil Separator, Return Tank, Pump Governor and Feed Water Heater recently installed in the engine room of the Manhattan Storage and Warehouse Company, 52nd St. and 7th Ave., is giving utmost satisfaction, as by its use we are enabled to return to our boilers, entirely free from oil, the water of condensation from the entire heating system as well as from numerous drips, hitherto discarded. The extreme high temperature of the boiler feed water maintained by the use of your apparatus and feed-water heater is sufficient alone to recommend it, irrespective of its other superlative merits. It affords me much satisfaction to thus add this entirely voluntary tribute to the many you have already received."

The Sterling Pipe Blower Co., of 60 Huyshope Ave., Hartford, Conn., have recently completed the installation of their improved systems for the following firms: Newport News Ship Building and Dry Dock Co., Newport News, Va.; Boston and Albany R. R. Co. Car Shops at West Springfield, Mass.; N. Y., N. H. & H. R. R. Co. Car Shops at Readville, Mass.; Penna. R. R. Co.'s Car Shops at Pitcairn and Altoona, Pa.; Smith-Premier Typewriter Co., Syracuse, N. Y.; American Stove Co., Cleveland. O.; Readsboro Chair Co., Wilmington, Vt.; Sitterding, Carneal, Davis Co., Richmond, Va.; and many others, and are constantly receiving orders from representative concerns in all parts of the country. Their business has increased so rapidly that they have recently doubled the capacity of their plant, installing in same a large number of the latest designs of Metal Working Machines, and are in a position to give their customers the very best attention. They have recently added to their line of special fittings a number of new devices, which greatly add to the efficiency and durability of the systems while in operation. Their New York Office is located at 85 Liberty St., New York City, and their Main Office and Factory is at Hartford, Conn. (60 Huyshope Ave.) at which Offices a force of contracting engineers are located, who would be pleased to call on intending purchasers and make designs and furnish estimates for complete systems for handling shavings and dust of all kinds without any charge for such services.

The Hartford Blower Company design and give estimates free of charge on Exhaust Systems of all kinds, as well as heating, ventilating and mechanical draft apparatus.

The Indicator Instruction Company of Scranton, Pa., issue a certificate to graduates showing proficiency. This certificate is valued by all engineers as it indicates that the holder has had as complete a course in the use of the indicator and its diagrams as it is possible to have. This course is under the supervision of the well-known Mr. A. C. Lippincott, and it teaches all about indicators, wheels, planimeters and how to make them; how to take cards and figure them. An indicator is loaned each student joining the course for his own practice.

The "Cunningham" Auto-Positive Self-Closing Water Gauge is a new device which has recently been put upon the market by the Standard Gauge Manufacturing Co., of Syracuse, N. Y., manufacturers of Pressure and Vacuum Gauge. Write for a catalogue as this device is original and has especial merit.

If you are going to the convention at Allentown do not forget to write early to Hotel Allen for rooms. Hotel Allen will be the headquarters for the American Order of Steam Engineers at their May convention and it is always best to be at headquarters to enjoy the most fun.

If you have a hot bearing that has given you trouble, write for some Dixon's Pure Flake Graphite. It solves the most difficult problems in lubrication.

Thomas Sparks, 1630 S. 16th St., Phila., Pa., bricklayer and contractor, makes fire brick work a specialty. Boiler furnaces relined at short notice. If anything is the matter with any brickwork around the plant, write to him for prices.

W. F. Ruwell's plant has been growing very rapidly. His office and works at 719-721 Noble Street, Philadelphia, are fitted up with the latest machinery for making general repairs to Corliss, Greene and other makes of steam engines. They also make a specialty of reboring cylinders and valve seats in place, repairing ice machines and pumps, metallic packing and piston rods.

The Grease that is all Grease, Keystone Grease. For this reason, the Keystone Lubricating Co., of 20th and Allegheny Ave., Phila., claim that Keystone Grease will do more in the way of lubricating and last longer than four gallons of oil and to prove it they send, express prepaid, a large sample can and a heavy brass grease cup to every engineer forwarding his name and business address.

When a person is sick, he goes to a doctor, so that when your elevator is sick, why not go to an elevator doctor? The Keystone Elevator Inspection and Repair Company, of 923 Locust St., Philadelphia, are experts in this line. They make a specialty of repairing elevators of all kinds, as well as putting in new ones. Any inquiry will receive prompt attention.

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The sheet gum "Auto" Packing, manufactured by Sayen and Schultz, 13th and Commerce Sts., Phila., is made from the finest grade of Para rubber. It is especially used for hydraulic and low pressure steam joints and gaskets. Send for a sample.

A sample of Stephenson Bar Belt Dressing, manufactured by the Stephenson Manufacturing Co., Albany, New York, will be sent to anyone mentioning "The Practical Engineer." If you have a squeaky belt or a loose belt, try this dressing and see the results.

Garlock High-Grade Packings are made specially in a hundred different styles for every variety of service. For this reason they are very adaptable for steam, gas, ammonia and hydraulic service. Write for a catalogue to the Garlock Packing Company, 604 Arch St., Phila., Pa.

It is getting steam traps down pretty fine, when one degree of heat will open and close the valve. This is done by the Heintz Steam Trap, manufactured by William S. Haines Co., 136 S. 4th St., Phila. Send for booklet "4."

The Weaver Steam Packing Co., Ltd., 144 N. Seventh St., Philadelphia, are manufacturers of "It Oils" Packing for packing the piston rod. Its name indicates the very thing that it does automatically and regularly to the piston rod. They also manufacture Steam Locomotive and Hydraulic Piston Packings.

Coal costs money and the less you are compelled to buy, the more money will be saved. A feature of this saving which is often neglected is the proper use of the feed pumps. If the feed pump is not convenient for the fireman, the water in the boiler will often be two gauges below the level or three gauge above, depending on the humor of the fireman. He is not to blame for this, when it is considered how often he must walk back and forth from the pumps to the boiler. It is a well-known fact that a uniform pressure can be maintained in the boiler more easily if the water level is uniform. A card to E. M. Carr, of New Castle, Ind., will bring you an interesting catalogue describing these things. He is the manufacturer of the well-known Carr Pump Governor, which saves hundreds of dollars in coal bills every year. These Governors are sent on 30 days' trial, to be returned if not satisfactory.

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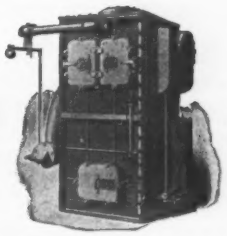

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American Order of Steam Engineers.

ORGANIZED APRIL 27, 1886.

An Order of Engineesr for Engineers and Engineers only.

DECLARATIONS OF PRINCIPLES

Believing that ability will bring its full value in this country, this Order shall at no time take part in strikes, nor in any way interfere between employer and employees. Recognizing their identity of interests, it shall take no part in any project or enterprise that shall interfere with perfect harmony between them ; neither shall it be used for political or religious purposes.

These principles shall not be amended or repealed except by unanimous vote of the Order.

Any member who shall be guilty of violating the principles of the Order shall be expelled.

OBJECTS.

First.—To promote a more thorough knowledge in its members of theoretical and practical steam engineering.

Second.—To assist members to obtain employment.

Third.—To help the sick, injured and distressed and bury the dead.

Fourth.—To establish a Widows' and Orphans' Fund.

Fifth.—To help members who shall become incapacitated from following the profession to obtain employment suited to their affliction.

Sixth.—To do our utmost to extend the license law throughout the United States.

Seventh.—To establish schools in which our members may study the highest branches of steam engineering.

MEMBERSHIP.

An applicant for membership must be an engineer between twenty-one and fifty years of age, and must be a white male citizen of the United States, of good moral character and be a believer in the Supreme Being, and be free from all physical infirmities.

He must have had three years' service in an engineering department, or if a machinist, or graduate of a technical institute, then one year's service, in such department, and in localities where engineers are required by law to be licensed, they must have such license, and must satisfy the investigating and examining committees of the council to which he applies as to his character and ability.

LIFE MEMBERSHIP.

Engineers who have passed the age limit may be admitted to life membership. They must possess the same qualifications and pass the same examination as are required in the next proceeding clause: They shall be entitled to all rights and privileges of the Order except they cannot vote on financial questions or for the election of officers or be entitled to any sick or death benefits.

DIRECTORY.

The Publication Committee of "The Practical Engineer" desires that the Corresponding Engineers of all Councils of the American Order of Steam Engineers send the name of their Chief Engineer and their own name and address, together with the time and place of meeting, to the Secretary of the Publication Committee immediately after each election of officers. Address, W. S. Wetzler, Secretary, 3717 Aspen St., Philadelphia.

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Delaware Council, No. 1, meets every Wednesday at S. E. Cor. Fourth and King Sts. Corresponding Engineer, A. E. Deakyne, 207 E. Fifth St., Wilmington.

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Energy Council, No. 2, meets every Wednesday of each month in Bauer Hall, Chesapeake and Elliott Sts. Corresponding Engineer, Phillip Kirkwood, 204 S. Washington St.

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Deputy Grand Chief for Western Pennsylvania, A. D. Hamilton, 2025 Forbes St., Pittsburg, Pa.

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Kensington Council, No. 3, meets every Thursday, at A. P. A. Hall, Frankford Ave. and Master St. Corresponding Engineer, Geo. W. Kennedy, 2052 East Fletcher St.

Southwark Council, No. 4, meets every Monday, at Cor. of Reed and Eighth Sts. Corresponding Engineer, J. C. McDowell, 1913 South Eighth St.

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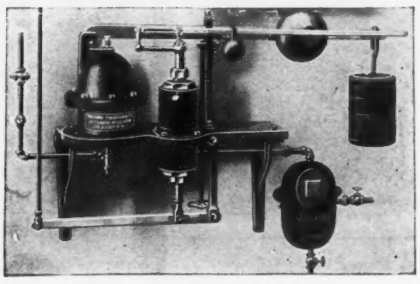

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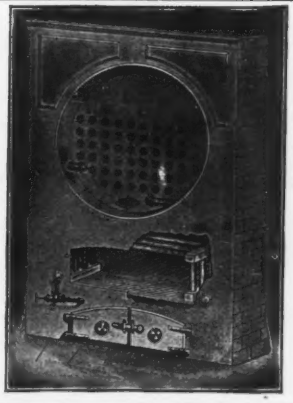

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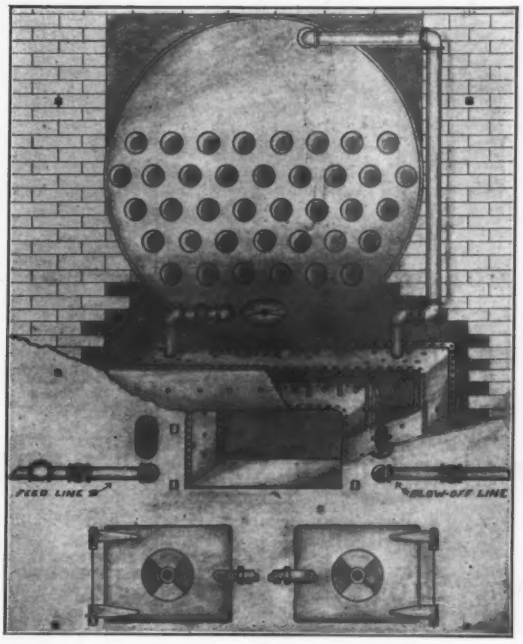

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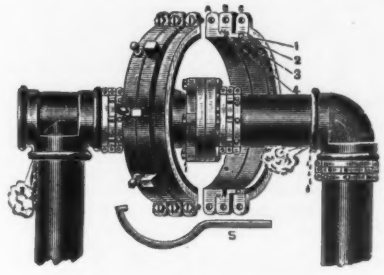

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ALLENTOWN.
Lehigh Council, No. 15, meets every Wednesday evening at 639 Hamilton St. Corresponding Engineer, A. P. Driesbach, 728 Chew St.

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Progress Council, No. 13, meets every Saturday evening at Diebert Hall, Ninth and Penn Sts., Room 4. Corresponding Engineer, Frank S. Miller, 3 West Franklin St.

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York Council, No. 16, meets every Wednesday Evening in the Jordan Block. Corresponding Engineer, Walter H. Long, 23 East Philadelphia St.

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Columbia Council, No. 18, meets every 1st and 3rd Saturdays, in Odd Fellows' Hall. Corresponding Engineer, W. J. Courtney, 804 Walnut St.

SUNBURY.
Sunbury Council, No. 19, meets every Monday evening in Zartman's Hall. Corresponding Engineer, Ed. Schrieber.

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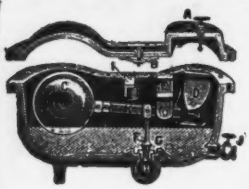

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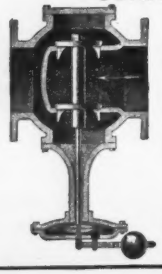

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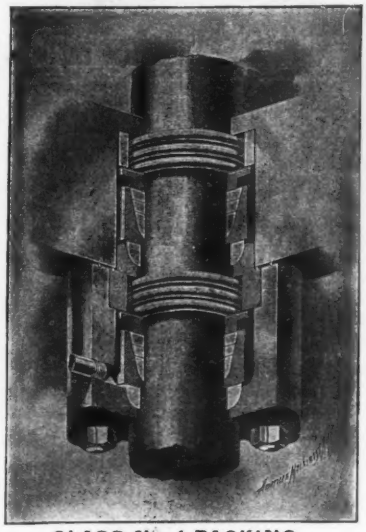

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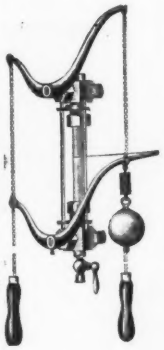

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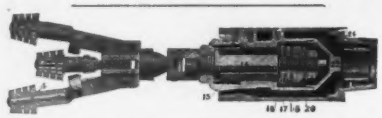
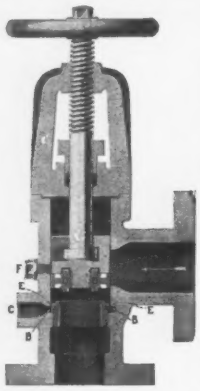
Boiler Tube Cleaners
Blow-off Valves



The Liberty Turbine Boiler Tube Cleaner

will clean tubes more thouroughly, at less cost, and in less time than can be done by other means.

This we guarantee.



We also make the **Niagara Turbine Tube Cleaner.** We have suit for infringement of patents against a user of the Weinland machine, and will sue all other infringers

The Faber Blow-off Valve

washes its face every time it is opened and closed.

A connection at C admits steam at boiler pressure to chamber B, whence it escapes through slot E all around the seat, and sweeps both seat and disk free from sediment just before closing. It will last as long as a steam valve without leaking.

Liberty Manufacturing Co.

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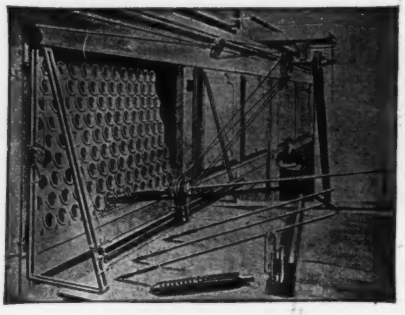

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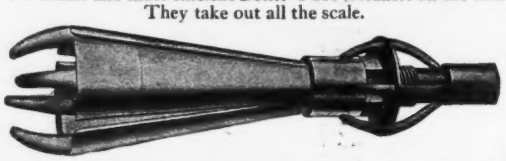
Are the oldest and most efficient Boiler Tube Cleaners on the market. They take out all the scale.



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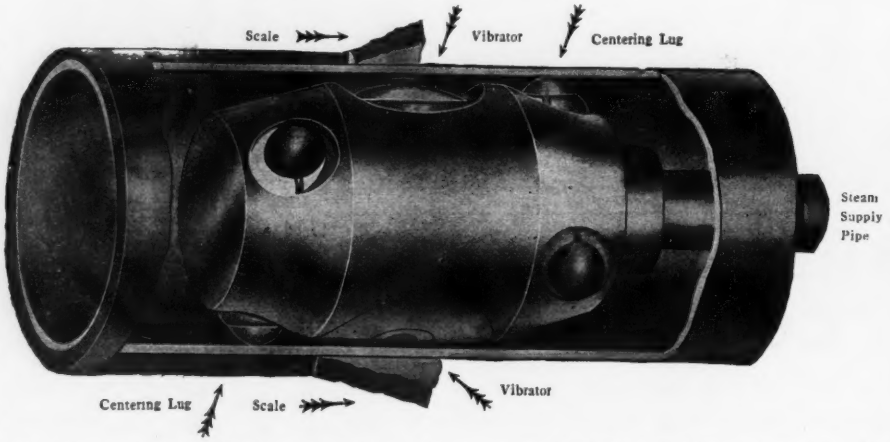

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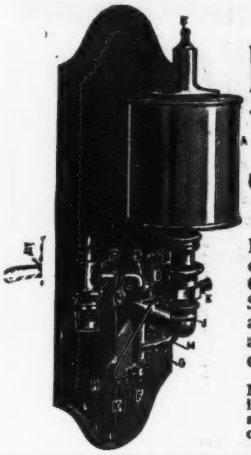

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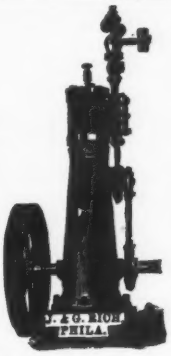

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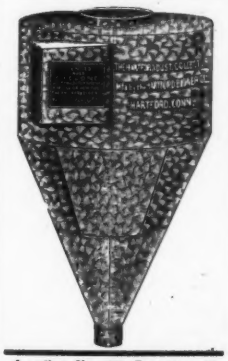

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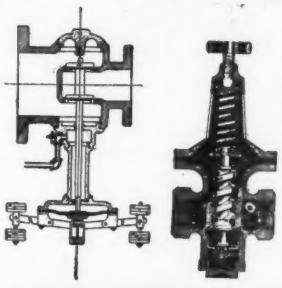

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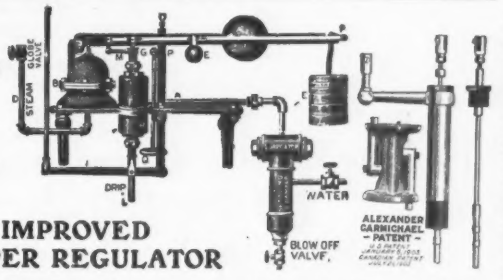

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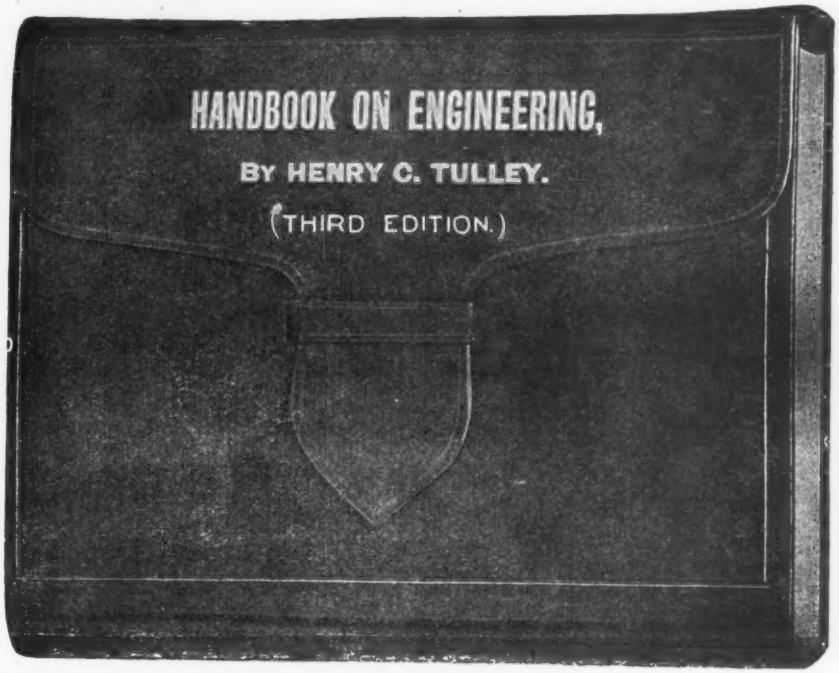

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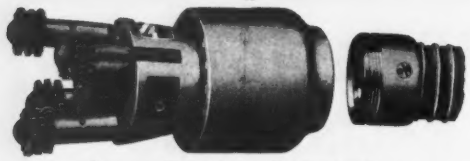

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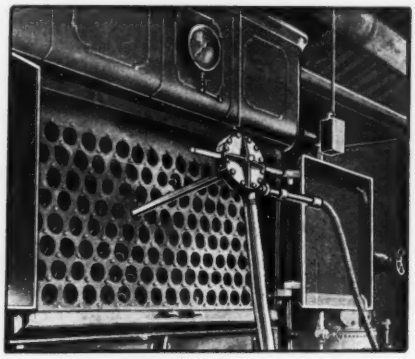

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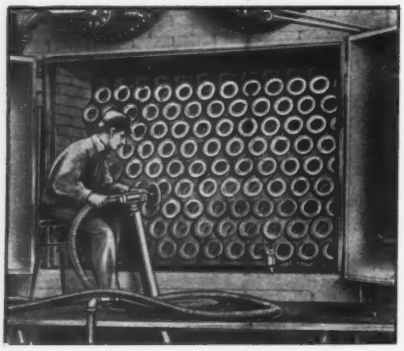

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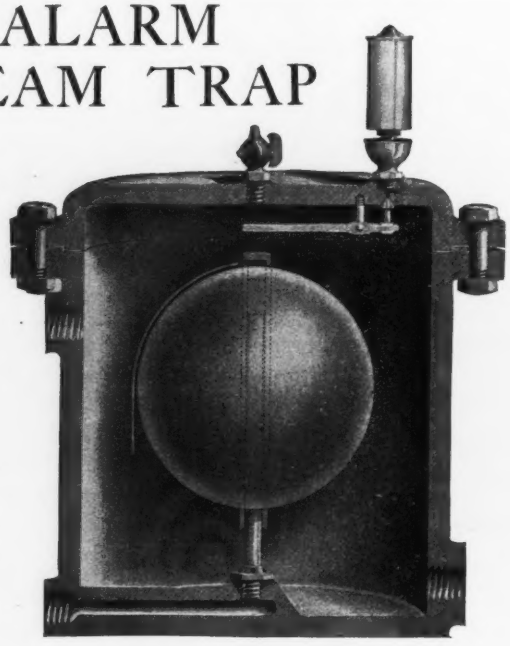

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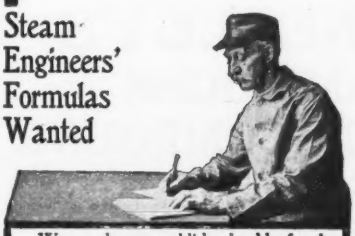

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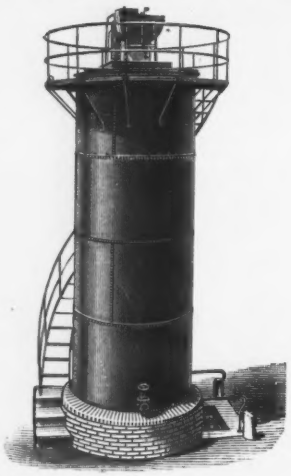

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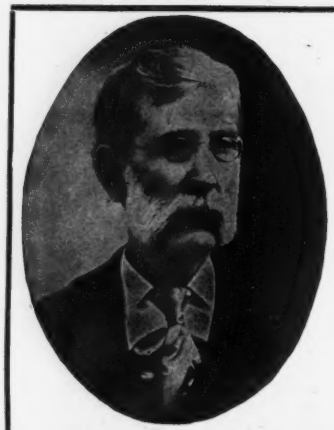

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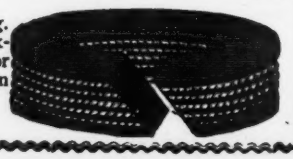

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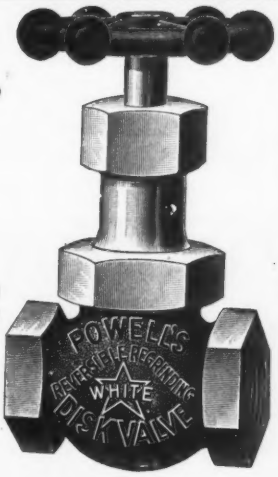

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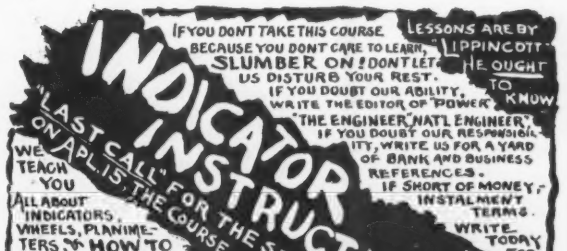
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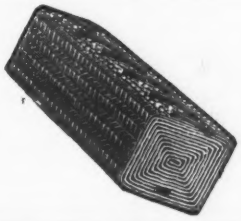

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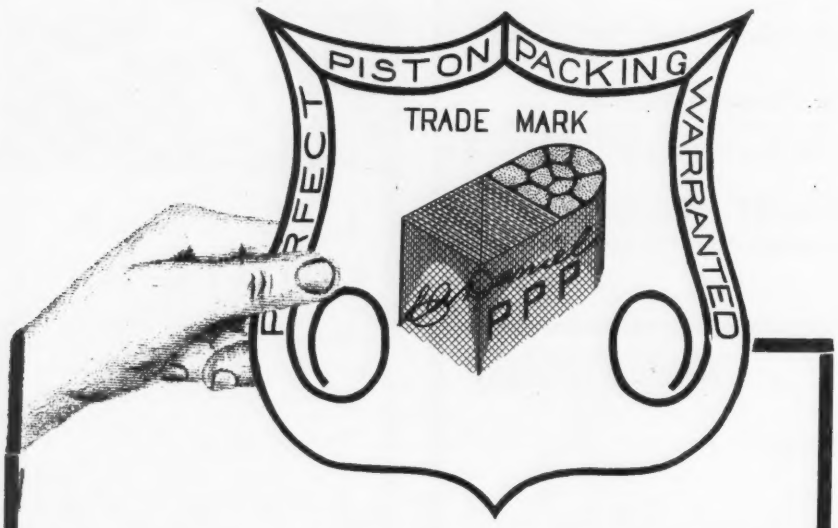

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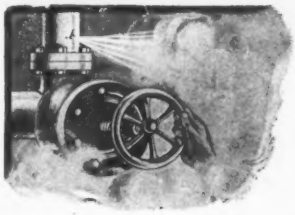

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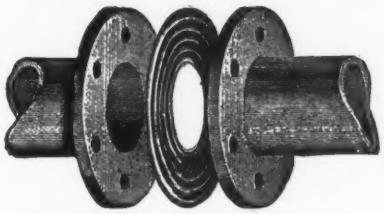

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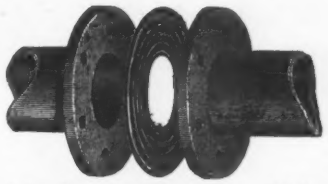

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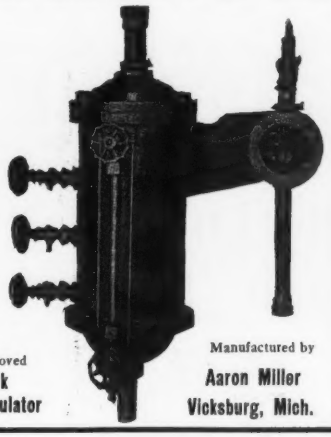

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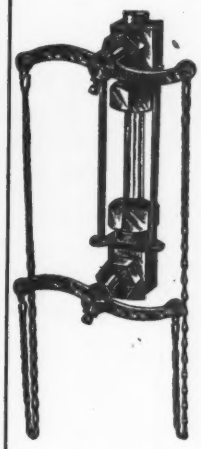

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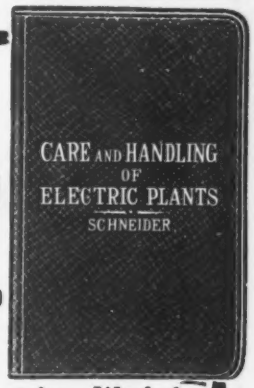

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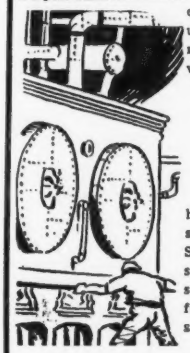

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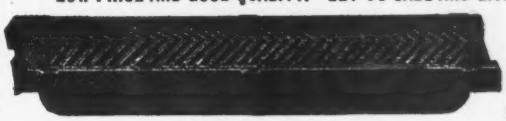

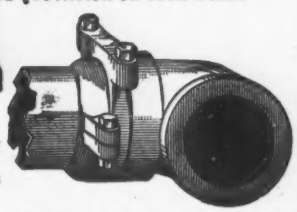

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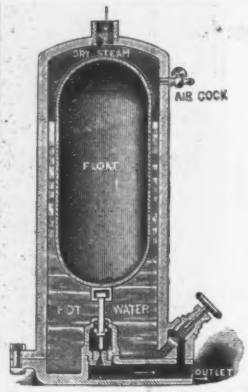

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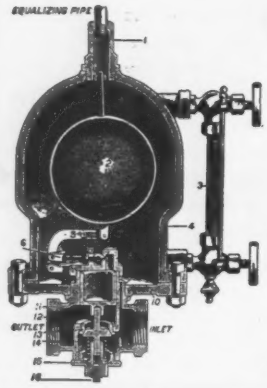

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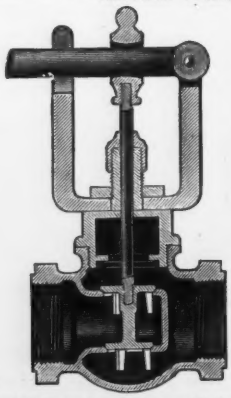

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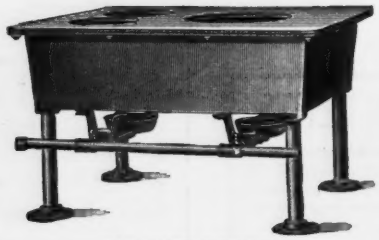
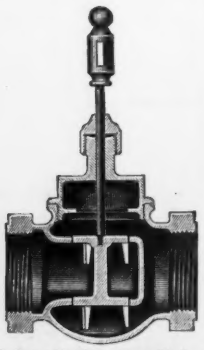


GAS GLUE HEATER



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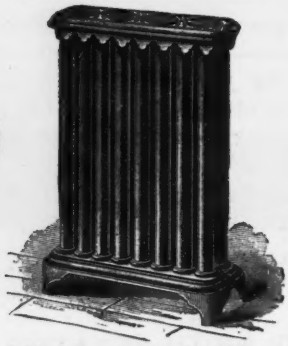

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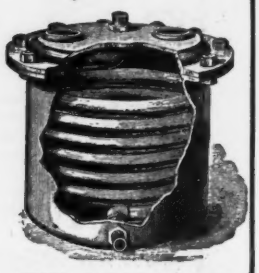

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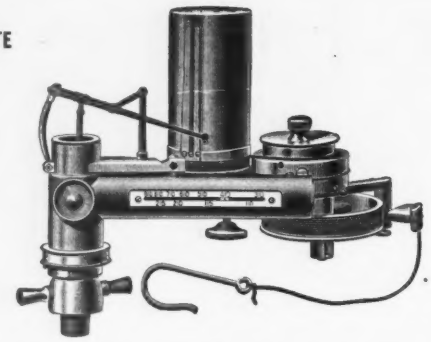

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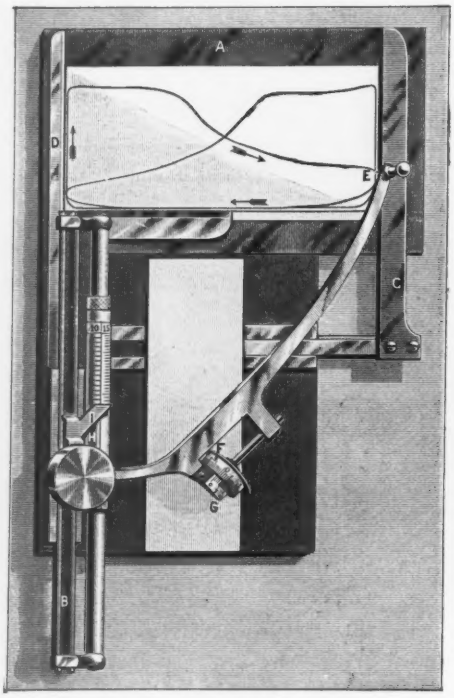

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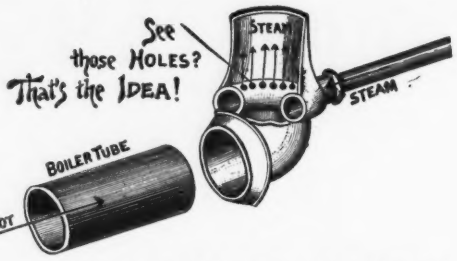

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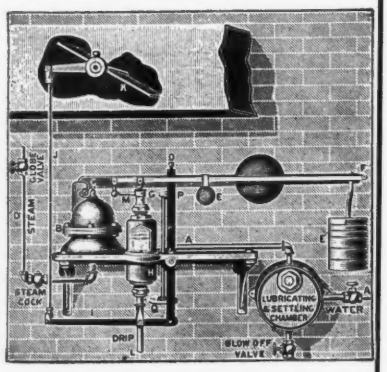

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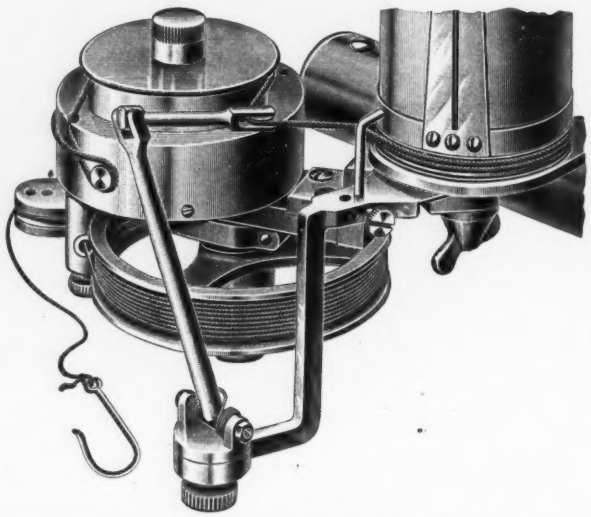

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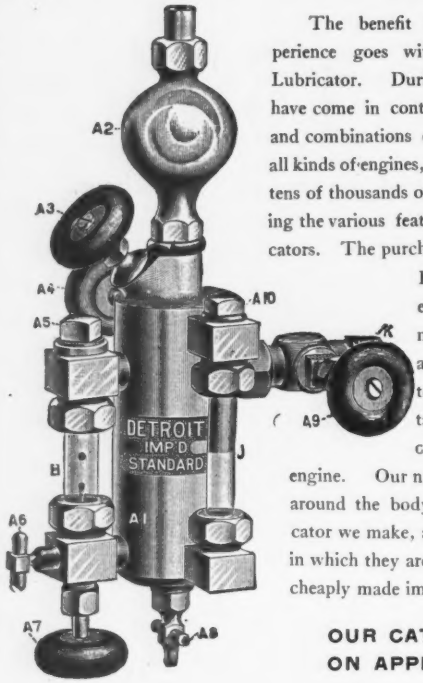

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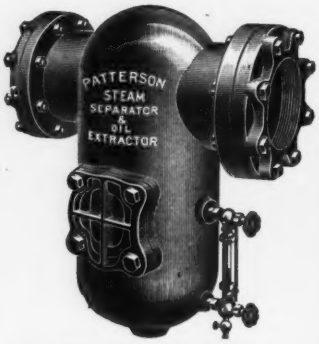

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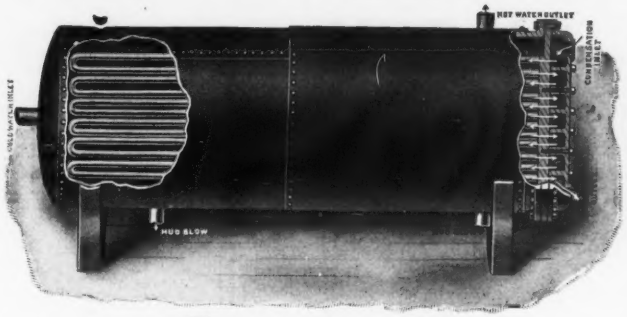

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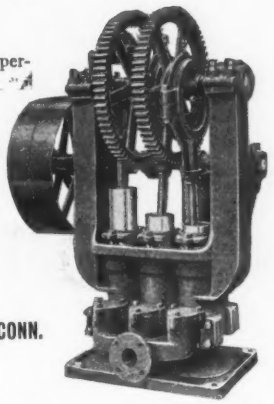
is a perfect type of the vertical triplex belt driven pump.



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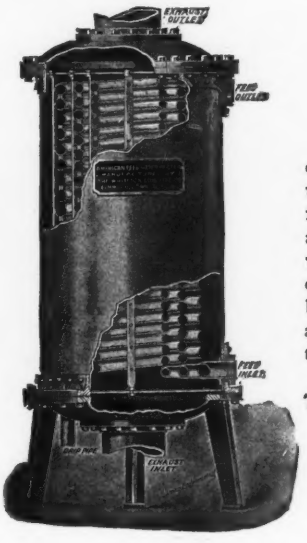

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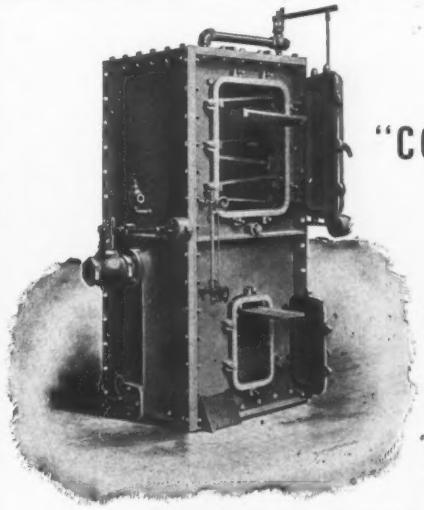

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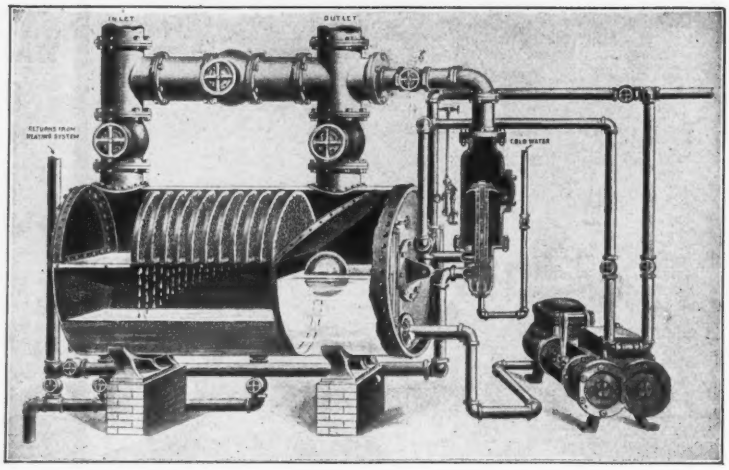

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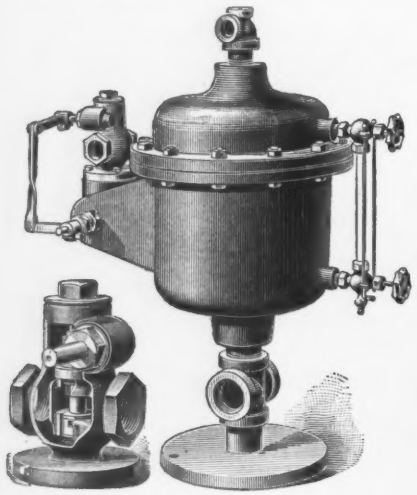

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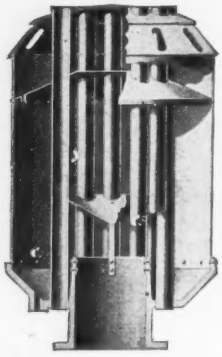

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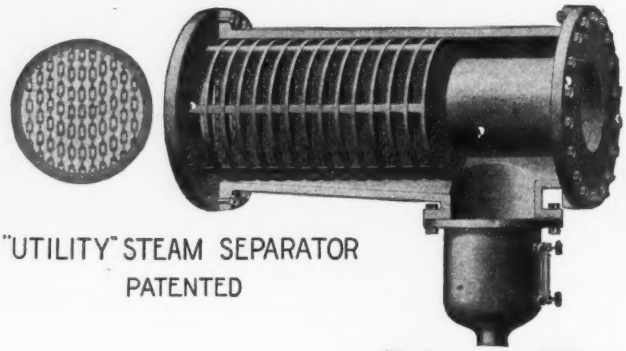

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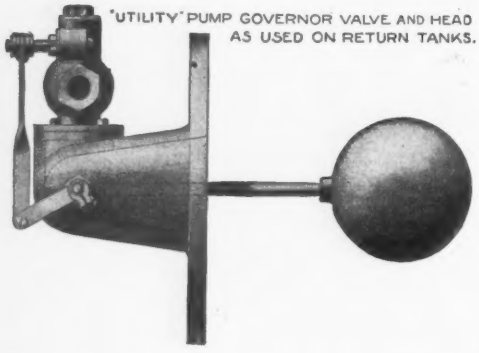

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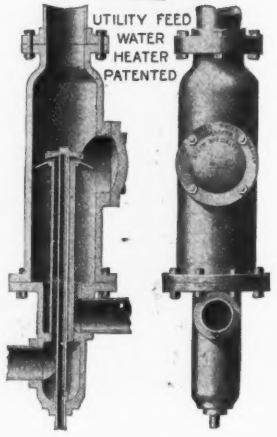

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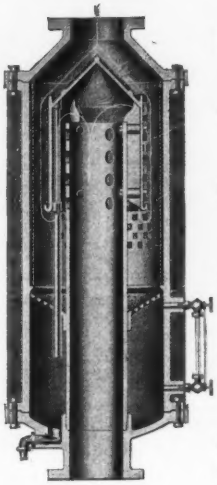

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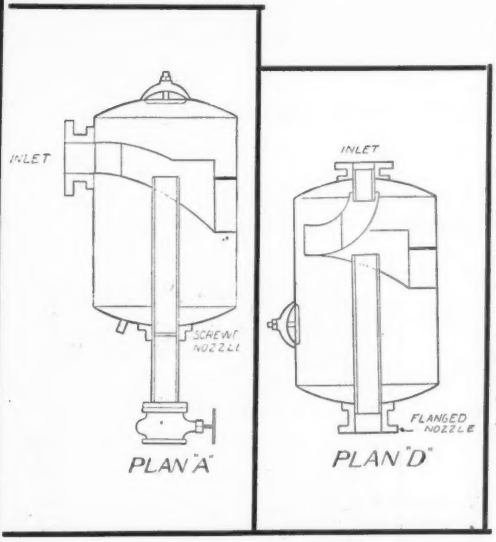

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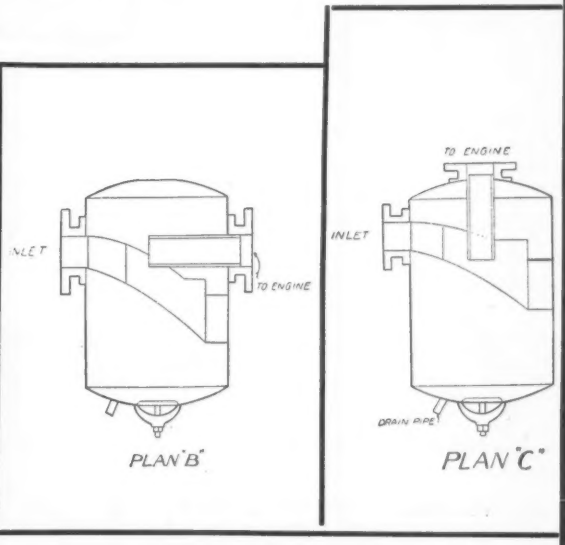

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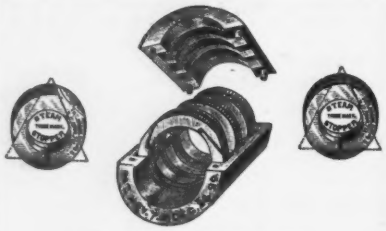

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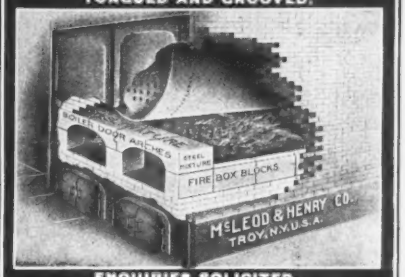

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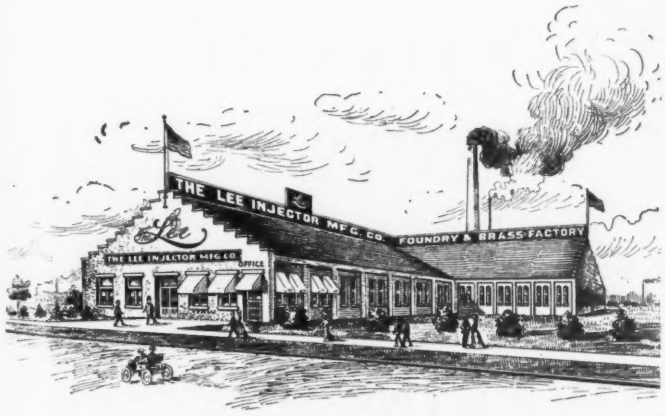

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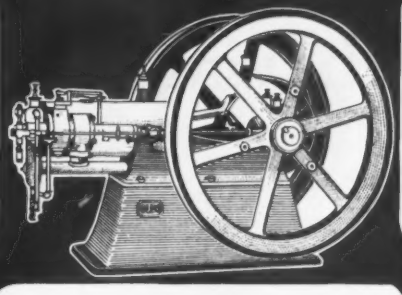

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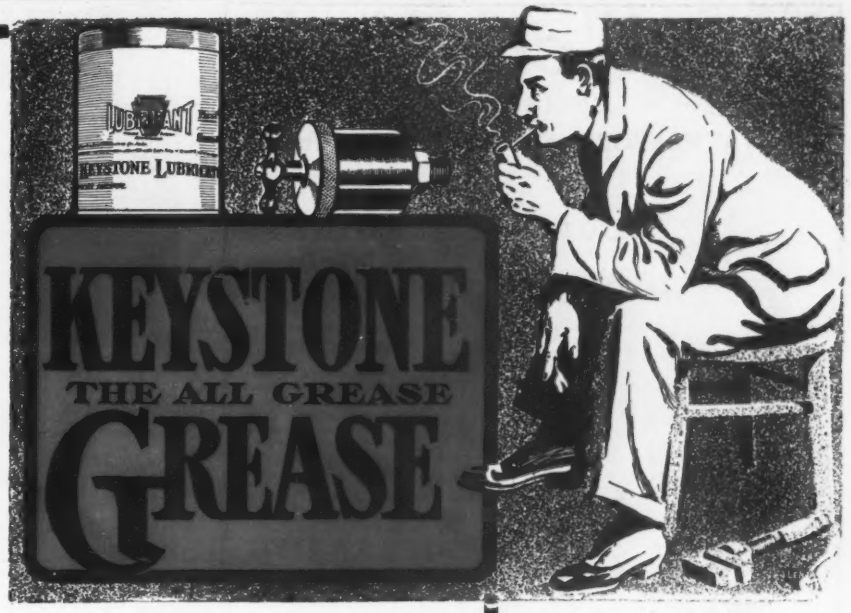

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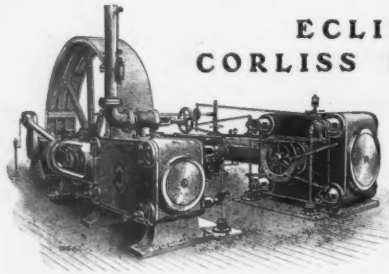

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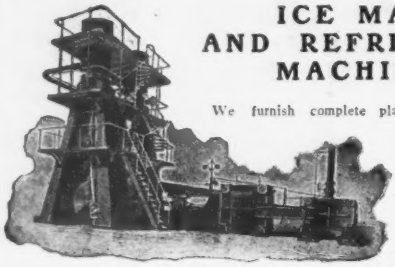

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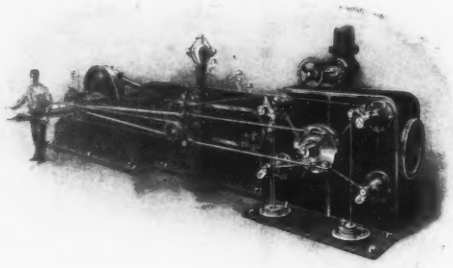

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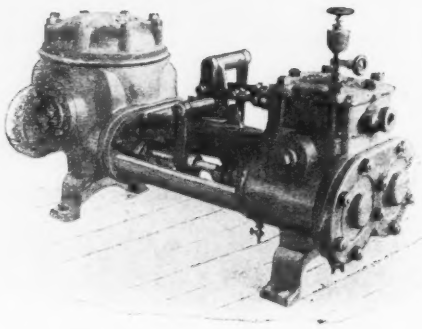

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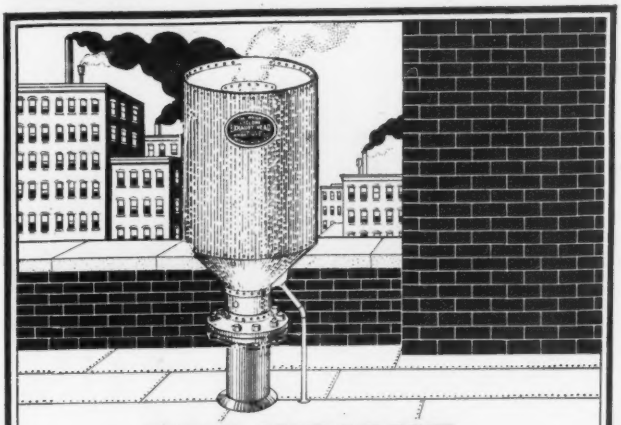

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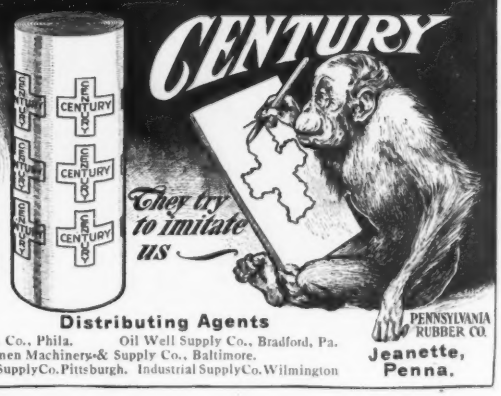

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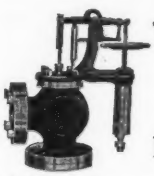

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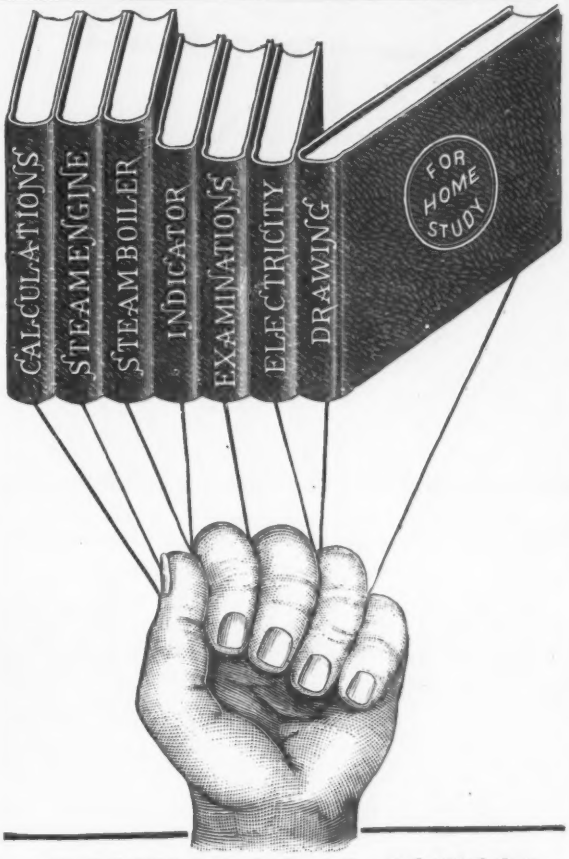

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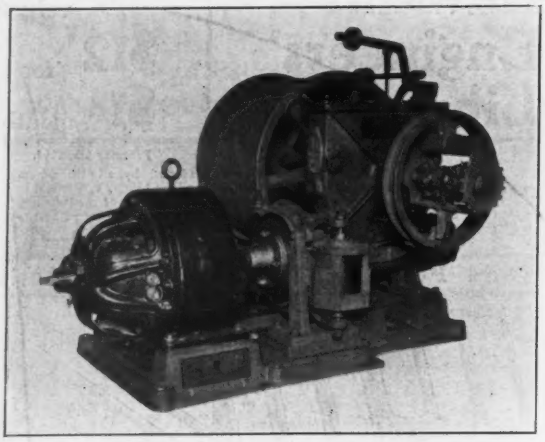

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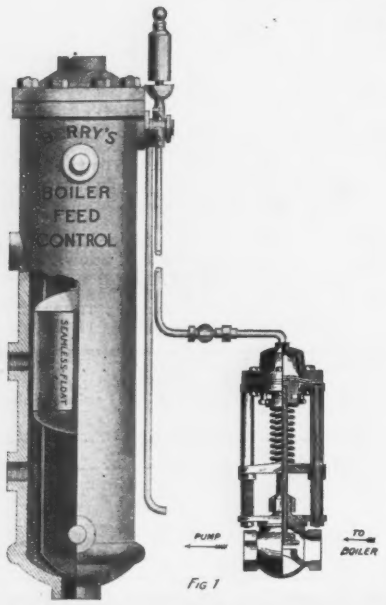

FIG 1

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JOINTS MADE WITH SEARCHLIGHT ARE NOT DISPLACED BY THE VIBRATION OF THE STEAM-LINE

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REPUBLIC IRON & STEEL COMPANY
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Yours truly,
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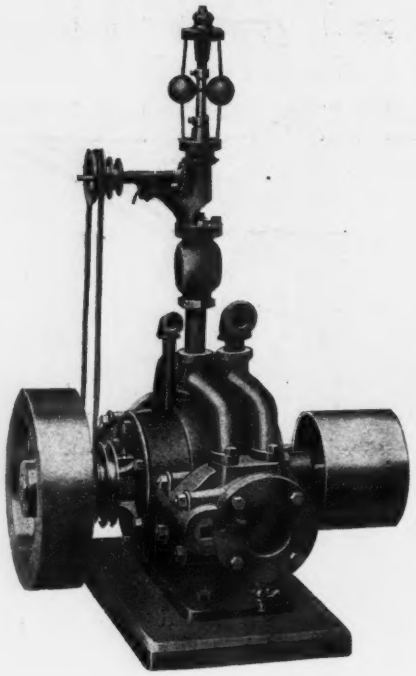

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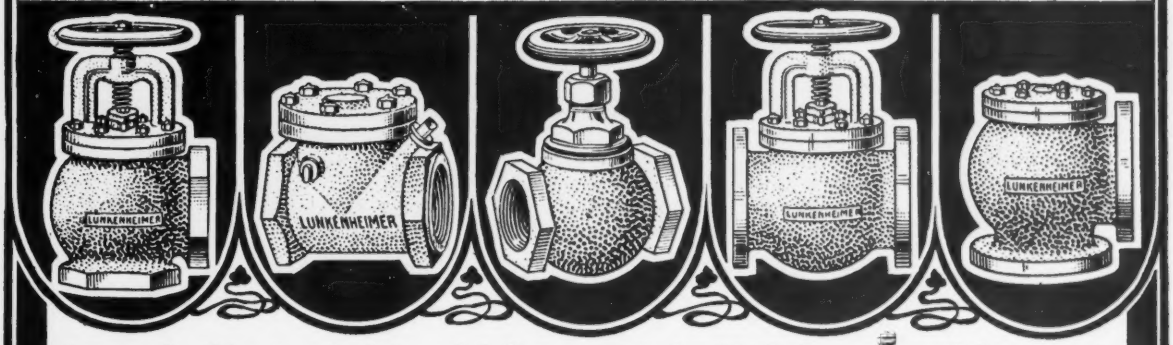

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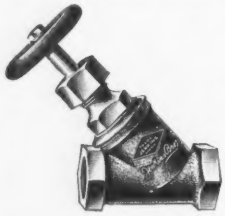

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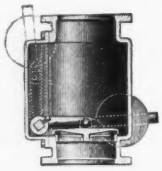

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